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The Influence of Physical Fitness Training on the Manual Material-Handling Capability and Road-Marching Performance of Female Soldiers

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This study examined the influence of a combined resistance and aerobic training program on the manual material-handling (MMH) capability and road-marching performance of female soldiers. Subjects were 21 healthy women, 13 of whom completed all phases of the investigation. They trained for 14 weeks, performing progressive resistance training 3 days per week and running with interval training 2 days per week. Compared to values obtained before training, soldiers increased the maximum mass they could lift from floor to knuckle height by 19% (68 to 81 kg, $p<0.001$) and from floor to chest height by 16% (49 to 57 kg, $p<0.001$). They improved by 17% their ability to lift 15 kg as many times as possible in 10 minutes (167 to 195 lifts, $p<0.001$), while perception of effort (measured with the Borg Rating of Perceived Exertion) did not change. They improved by 4% their maximal effort road march time over a 5-km distance, carrying a 19-kg load mass (44.7 to 43.1 min, $p=0.02$). While total body mass did not change, body fat mass was reduced by 9% (18.8 to 17.2 kg, $p=0.036$) and fat-free mass increased by 6% (48.2 to 51.0 kg, $p<0.001$). A short-term physical training program, conducted about 1 hour per day, 5 days per week can substantially improve female soldiers' MMH capability, result in a small improvement in road-marching ability, and provide favorable changes in body composition (increased fat-free mass and decreased body fat).

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THE INFLUENCE OF PHYSICAL FITNESS TRAINING ON THE MANUAL MATERIAL-HANDLING CAPABILITY AND ROAD-MARCHING PERFORMANCE OF FEMALE SOLDIERS

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March 1996

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FOREWORD

In fiscal year (FY) 94, the U.S. Congress allocated funds for executing the Defense Women's Health Research Program. The objective of this program was to stimulate applied research into women's occupational health issues. Administrative control of the program was given to the U.S. Army Medical Research and Material Command (MRMC), which solicited research proposals that were reviewed on the basis of military relevance and scientific merit.

One of the proposals submitted by the Human Research and Engineering Directorate (HRED) of the U.S. Army Research Laboratory was a study of the influence of physical fitness training on the manual material-handling capability of women. This proposal was accepted for funding by MRMC in September 1994. A full research protocol was approved by the HRED Human Use Committee on 20 December 1994 and by the MRMC Human Use Review and Regulatory Affairs on 24 January 1995.

The following command groups of three military units at Aberdeen Proving Ground were briefed about the study in November 1994: the Aberdeen Military Police Company (AMPC), Headquarters Support Troop (HST), and Combat Systems Test Activity (CSTA), now Aberdeen Test Center (ATC). The commanders agreed to allow soldiers to participate in the study. A human subjects briefing was conducted in January 1995, and 21 soldiers volunteered for the investigation. The study was conducted between 15 March 1995 and 30 June 1995. This report details the background and findings of this investigation.

CONTENTS

EXECUTIVE SUMMARY

This study examined the influence of a combined resistance and aerobic training program on the manual-material handling (MMH) capability and road-marching performance of female soldiers. Subjects were 21 healthy women, 13 of whom completed all phases of the investigation. They trained for 14 weeks, performing progressive resistance training 3 days per week and running with interval training 2 days per week. Compared to values obtained before training, soldiers increased the maximum mass they could lift from floor to knuckle height by 19% (68 to 81 kg, $p<0.001$) and from floor to chest height by 16% (49 to 57 kg, $p<0.001$). They improved by 17% their ability to lift 15 kg as many times as possible in 10 minutes (167 to 195 lifts, $p<0.001$), while perception of effort (measured with the Borg Rating of Perceived Exertion) did not change. They improved by 4% their maximal effort road march time over a 5-km distance, carrying a 19-kg load mass (44.7 to 43.1 min, $p=0.02$). While total body mass did not change, body fat mass was reduced by 9% (18.8 to 17.2 kg, $p=0.036$) and fat-free mass increased by 6% (48.2 to 51.0 kg, $p<0.001$). A short-term physical training program, conducted about 1 hour per day, 5 days per week can substantially improve female soldiers' MMH capability, result in a small improvement in road-marching ability, and provide favorable changes in body composition (increased fat-free mass and decreased body fat).

THE INFLUENCE OF PHYSICAL FITNESS TRAINING ON THE MANUAL MATERIAL-HANDLING CAPABILITY AND ROAD-MARCHING PERFORMANCE OF FEMALE SOLDIERS

INTRODUCTION

Manual material handling (MMH) is the act of lifting, lowering, carrying, holding, pushing and pulling by hand and without the aid of mechanical devices (National Institute of Occupational Health and Safety, 1981; Genaidy, Gupta, & Alshedi, 1990). This type of labor is one of the most stressful for American workers as evidenced by the fact that it accounts for the largest number of compensable work injuries (National Safety Council, 1972; National Institute of Occupational Health and Safety, 1981). In the U.S. Army, military occupational specialities (MOSs) with MMH requirements comprise 83% of all MOSs, accounting for the large majority of enlisted spaces. More than 175 MOSs require occasional lifting of 45 kg or more and frequent lifting of 23 kg or more (Headquarters, Department of the Army, 1994). For example, the mass of a single 155-mm self-propelled howitzer round is 44 kg. In a typical field artillery scenario, a howitzer may be required to fire 275 rounds per day with only one or two individuals lifting these rounds (Knapik et al., 1987; U.S. Army Field Artillery School, 1984). Another MMH example is the cargo specialist (MOS 88H) who is required to lift 240 kg as part of a four-soldier team (prorated at 60 kg per soldier); he or she frequently lifts and carries 64 kg as part of a two-soldier team (prorated at 32 kg per soldier). A two-soldier chemical operations team (MOS 54B) must frequently lift oil drums weighing 215 kg from the ground onto a truck (Headquarters, Department of the Army, 1994).

An increasing number of MOSs with heavy lifting requirements have been opened to women since their integration into the regular Army in 1978 (Moden, 1989; Myers, Gebhardt, & Crump, 1984). There is an ongoing debate about opening additional MOSs (Walker, 1994), many of which will also have heavy lifting requirements. The proportion of women in the U.S. Army is expanding; in 1983, 9.6% of the U.S. Army was comprised of women (Defense Almanac, 1983); in 1992, it was 11.3% (Defense Almanac, 1992); in 1994, 19% of all new recruits were women (Morganthau, Bogert, Barry, & Vistica, 1994).

Women have substantially less lifting ability than men (Myers et al., 1984; Vogel, 1985), presumably because of women's lower muscle strength. Women have about 55% the strength of men in the upper body (arms and chest) and 72% the strength of men in the lower body (legs). Overall, the strength of women is about 63% that of men (Knapik, Wright, Kowal, & Vogel,

1980; Laubach, 1976). Much of this strength difference may be accounted for by the lower muscle mass of women (Baumgartner, Rhyne, Troup, Wayne, & Garry, 1992; DeKoning, Binkhorst, Kauer, & Thijssen, 1986; Knapik et al., 1980; Wilmore, 1974), since the major determinant of strength appears to be the cross-sectional area of muscle tissue (Maughan, 1984). Systematic resistance training has been shown to increase the strength and muscle mass of both men and women (Cureton, Collins, Hill, & Mcelhannon, 1988; O'Shea & Wegner, 1981; Wilmore, 1974; Wilmore et al., 1978) and may be a method for increasing women's capability in MMH tasks.

Using resistance training to improve MMH capability is a relatively new concept (Asfour, Ayoub, & Mital, 1984). Traditional ergonomic approaches to reducing worker job stress during MMH have largely focused on redesigning the working environment through changes in equipment or task requirements (Kantowitz & Sorkin, 1983). However, cost considerations and interference with existing work processes often limit the usefulness of these latter techniques. For example, it is difficult to modify the shape or mass of a howitzer shell because these factors are dictated by the ballistic and aerodynamic nature of the round and the charge necessary for the explosive effect.

The major purpose of this investigation was to examine the influence of a traditional physical fitness program on improving the MMH capability of women. The program emphasized muscular strength and endurance exercises since this is the type of fitness training most likely to improve MMH capability (Asfour et al., 1984; Sharp, Harman, Boutilier, Bovee, & Kraemer, 1993). However, the program also included aerobic training since this component of physical fitness may be necessary to enhance many of the other tasks that soldiers must perform (Headquarters, Department of the Army, 1992).

BACKGROUND

This section examines studies of female adaptations to resistance training and critically analyzes studies regarding improvement of MMH capability through resistance training.

Development of Muscular Strength and Endurance

Progressive resistance exercise is the most commonly employed technique for improving muscular strength and endurance. The concept of progressive resistance was developed by CPT Thomas Delorme during his work on rehabilitating soldiers following WWII (Delorme, 1945;

Delorme, 1948). He noted a difference between low resistance, high repetition exercise, which developed endurance, and high resistance, low repetition exercise, which developed strength. He formed the concept of the one-repetition maximum (1RM) and ten-repetition maximum (10RM), which are the maximal amount of weight that can be lifted by a particular muscle group one time or ten times, respectively. Delorme prescribed that individuals should train with the 10RM, performing three sets using each muscle group (Delorme, 1948). He noted that the mass lifted should be gradually and systematically increased (hence the term "progressive").

Fifty years of subsequent research have verified and expanded many of these ideas. There appears to be a continuum of "repetitions maximums" (RM) which has different effects on muscular strength versus muscular endurance (Anderson & Kearney, 1982). Maximal strength appears to be most effectively developed with multiple sets of 3 to 6RM (Atha, 1981; Fleck & Kraemer, 1988); muscular endurance is best developed with multiple sets at higher repetitions (i.e., 15 to 20 repetitions) (Fleck & Kraemer, 1988). Repetitions intermediate to these (e.g., a 10RM) develop both strength and endurance but neither optimally.

Table 1 shows studies that have examined changes in women's strength in response to progressive resistance programs. Each investigation uses a different training program, possibly accounting for the wide variations in results. Two studies (Capen, Bright, & Line, 1961; Oyster, 1979) did not specify their training programs and used testing devices that differed from devices used for training (i.e., dynamometry [Capen et al., 1961] or cable tensiometry [Oyster, 1979]). Only two studies were 12 weeks long (Butts & Price, 1994; Gettman, Ward, & Hagan, 1982), with most 10 weeks or fewer. The one long-term study (24 weeks) (Brown & Wilmore, 1974) used nationally ranked track and field athletes, only one of whom had previous, consistent experience with resistance training. These athletes are probably not representative of the general population in terms of strength gains but showed impressive improvements over the training period.

Strength training studies that have examined both men and women during the same training regimes show that females generally made greater relative gains in strength than their male counterparts (Cureton et al., 1988; Gettman et al., 1982; Hunter, 1985; Wilmore, 1974; Wilmore et al., 1978). However, the men's absolute strength always exceeded that of women, and after training, the average woman did not achieve the absolute strength of the average untrained man.

Table 1

Changes in Strength in Various Resistance Training Studies

Study	Training program	Exercise	Absolute (Kg pre→Kg post) M	Absolute (Kg pre→Kg post) F	Relative (percent Δ) M	Relative (percent Δ) F
(Capen et al., 1961)	10 weeks, 3 times/wk rest of pgm unspecified	R.H. grip		34→36		6
		L.H. grip		28→30		7
		back		104→110		11
		leg		250→321		25
(Brown & Wilmore, 1974)	24 weeks, 3 times/wk, (8wks-6sets: 10,8,7,6,5,4 reps) (16wks-5sets: 10,6,5,4,3 reps)	bench press		50→68		38
		half squat		142→160		29
(Wilmore 1974)	10 weeks, 2 times/wk, 2 sets:7-16 reps	leg press	407→513	229→387	26	30
		arm curl	39→46	20→22	19	11
		bench press	66→77	25→32	17	29
		hand grip	51→54	29→33	5	13
(Mayhew & Gross, 1974)	9 weeks, 3 times/wk, 2 sets:10 rm (circuit training)	leg press		75→110		48
		bench press		22→28		27
		arm curl		12→17		39
		hand grip		35→38		7
(Wilmore et al., 1978)	10 weeks, 3 times/wk, 3 sets: 40-55% of 1RM (circuit training)	bench press	64→70	31→38	8	20
		shoulder press	53→56	30→34	6	14
		arm curl	35→39	NT[a]	11	NT[a]
		upright row	46→49	24→27	6	12
		lat pull	68→73	26→35	7	36
		leg press	185→197	84→107	7	27
		leg curl	39→42	19→29	6	53
		leg extension	66→76	NT[a]	15	NT[a]
(Cureton et al., 1988)	9 weeks, 3 times/wk, 2 sets of 10 rm	arm curl	32→42	16→25	36	59
		triceps extension	33→43	18→25	35	42
		leg curl	65→73	34→42	13	24
		leg extension	80→105	42→58	29	34
(Bailey et al., 1987)	10 weeks, 4 times/wk, 3 sets of 80% 1RM	leg press		NR[b]		21
		leg extension		NR[b]		50

Table 1 (continued)

(O'Shea & Wegner, 1981)	7 weeks, 3 times/wk: 2 days-70% 1RM,4sets,5reps; 1 day-50% 1RM, 3 sets, 6-8 reps	bench press	88→95	43→49	8	13
		squat	104→124	76→96	16	24
(Gettman et al., 1982)	12 weeks, 3 times/wk 3 sets of 12-15 reps of 40% of 1RM (circuit training)	bench press (CWT[c])	66→75	30→36	14	20
		leg press (CWT[c])	196→227	113→133	16	18
		bench press (CWT&run)	68→82	29→35	21	21
		leg press (CWT&run)	191→232	104→131	21	26
(Hunter, 1985)	7 weeks, 2 groups: 3 times/wk, 3 sets, 7-10 reps; 4 times/wk, 2 sets,7-10 reps	bench press (3/wk)	69→77	26→31	12	20
		bench press (4/wk)	59→69	27→36	17	34
(Oyster, 1979)	7 weeks, 2 times/wk, rest of program unspecified	shoulder flexion		65→69		6
		shoulder extension		74→75		1
		elbow flexion		104→95		-9
		elbow extension		50→48		-4
		knee extension		165→247		50
		ankle p. flex		194→247		27
		hip flexion		100→120		20
		hand grip		79→87		10
(Stone & Coulter, 1994)	9 weeks, 3 times/wk, 3 groups: 3 sets, 6-8 reps; 2 sets, 15-20 reps; 1 set, 30-40 reps	BP (3 set)		29→35		19
		squat		52→69		33
		BP (2 set)		31→37		17
		squat		49→64		31
		BP(2 set)		33→37		12
		squat		59→74		25
(Butts & Price, 1994)	12 weeks, 3 times/wk, 1 set of 8-10 rep max (nautilus machines)	hip&back leg ext leg curl chest pullover multicurl multi-tri abdominal		No 1RM		No 1RM

[a]NT=not tested [b]NR=not reported [c]CWT=circuit weight training

Table 2 shows studies that have examined women's body composition changes in response to resistance training. For programs as long as 12 weeks, increases as great as 2.3 kg of whole body fat-free mass and decreases of 1.9 kg of body fat were seen. The 24-week study that used the elite track and field athletes (Brown & Wilmore, 1974) showed changes that were similar to the short-term studies. Studies making direct comparisons between men and women show similar absolute changes (Gettman et al., 1982; Hunter, 1985; Wilmore, 1974).

Table 2

Changes in Body Composition Following Resistance Training in Various Studies

		Relative (percent Δ) body composition changes				Absolute (Kg Δ) body composition changes			
		Fat-free mass		Body fat		Fat-free mass		Body fat	
Study	Group	M	F	M	F	M	F	M	F
(Brown & Wilmore, 1974)			+1.7		-3		+1.0		-1
(Wilmore1974)		+1.9	+2.4	-10	-8	+1.1	+1.2	-1	-1
(Mayhew & Gross, 1974)			+3.7		-7		+1.5		-2
(Bailey et al., 1987)			+2.0				NR*		
(O'Shea & Wegner, 1981)			+0.6		+2.3		+0.3		+0.6
(Hunter, 1985)		+0.7	+0.6	-2	-7	+0.5	+0.3	-1	-1
(Butts & Price, 1994)			+2.9		-7.4		+1.3		-2.2
(Gettman et al., 1982)	CWT**	+2.3	+3.9	-18.2	-10.4	+2.7	+1.9	-3.8	-1.9
	CWT & run	+2.7	+2.2	-14.8	-12.7	+2.3	+1.0	-2.9	-2.3

*NR=not reported
**CWT=circuit weight training

Table 3 shows changes in selected body girths in response to resistance training programs. In general, the magnitude of the changes is very small. This could be attributable to the nature of the training programs which emphasized the development of muscular strength and endurance rather than muscle hypertrophy directly. Higher training volumes (more sets and repetitions) may be necessary if the goal of the training program is hypertrophy (Stone, O'Bryant,

Garhammer, McMillian, & Rozenek, 1982). Girth changes appear to be similar in men and women in the two studies that made direct comparisons (Hunter, 1985; Wilmore, 1974). One study used computed axial tomography (CAT) scans to directly examine muscle hypertrophy in men and women (Cureton et al., 1988). Changes in upper arm muscle cross-sectional area were examined before and after 9 weeks of arm curl and triceps extension training. Relative increases in arm muscle cross-sectional area were 16% for men and 23% for women, and these were not significantly different.

Table 3

Selected Changes in Body Girth as a Result of Resistance Training in Various Studies

	Relative girth changes (percent Δ)		
Study	Measures	M	F
(Brown & Wilmore, 1974)	Thigh		0.3
	Deltoid		5.9
	Biceps (flexed)		1.6
	Biceps (extended)		3.1
(Wilmore, 1974)	Thigh	0.5	0.4
	Deltoid	2.7	1.3
	Biceps (flexed)	2.4	2.2
	Biceps (extended)	2.4	2.4
	Abdomen	0.7	0.9
(Mayhew & Gross, 1974)	Forearm		2.1
	Biceps		2.7
	Shoulder		2.0
	Chest		3.1
(Bailey et al., 1987)	Thigh		1
(Hunter, 1985)	Biceps	2.9	2.5
	Chest	1.2	-0.8
(Oyster, 1979)	Biceps (relaxed)		-1.4
	Chest (relaxed)		-1.2
	Deltoid		-0.9
	Thigh		-1.8

Physical Training and MMH Tasks

Studies that have examined physical training and MMH capability can be divided into two subcategories. The first subcategory includes studies that use the same MMH task for testing and training (task-specific training studies). The second subcategory includes investigations that use more generalized and traditional training programs that do not include the MMH tasks in the training program (general training studies).

MMH and Task-Specific Training Studies

In the first study of this type, Asfour et al. (1984) had 10 male college students train for a total of 30 sessions (5 days per week, 6 weeks). For strength training, they performed three sets of a six-repetition maximum (6RM), lifting a box to three different heights (nine sets total). For muscular endurance training, they performed 10 minutes of continuous lifting of 14 to 20 kg at rates of six to nine lifts per minute. For cardiovascular endurance, they trained on a cycle ergometer, 30 minutes each session. At the end of the program, improvements in the 1RM box lift were 41% for the floor to 76-cm lift (78 to 110 kg, $p<0.01$), 99% for the 76- to 127-cm lift (44 to 88 kg, $p<0.01$) and 55% for the floor to 127-cm lift (51 to 79 kg, $p<0.01$). Cardiorespiratory endurance (VO_2max estimated from heart rate) also improved 23%.

Sharp and Legg (1988) used a psychophysical approach. Eight male soldiers selected the maximal mass they thought they could lift to a distance of 132 cm for 1 hour at a rate of six lifts per minute. Subjects were trained with the self-selected loads (i.e., continuously subject adjusted) for 20 sessions (5 days per week, 4 weeks), lifting in two 15-minute periods each session. At the end of training, the self-selected box mass had increased 26% (25 to 31 kg, $p<0.05$), 1RM box lift increased 7% (64 to 68 kg, $p<0.05$), and there was no change in perceived exertion during the psychophysical task.

A number of studies have been performed by Genaidy and coworkers (Genaidy, Davis, Delgado, Garcia, & Al-Herzalla, 1994; Genaidy, 1991; Genaidy, Bafna, Sarmidy, & Sana, 1990; Genaidy, et al., 1990; Genaidy, Mital, & Bafna, 1989; Guo, Genaidy, Warm, Karwowski, & Hidalgo, 1992). All these investigations used tasks involving a complex series of lifting, carrying, pushing and pulling movements. Subjects trained for periods of 2.5 to 6 weeks (8 to 24 sessions) in the same task for which they were tested. In general, training resulted in a) progressive improvements in endurance time (time to volitional exhaustion) ranging from 34% to 1350%; b) increases in the isometric strength of the shoulders, arms, legs, and back; c) little or no

change in the rating of perceived exertion; and d) a decrease in activity heart rate, suggesting an improvement in cardiovascular endurance.

MMH and General Physical Training Studies

Only two studies (Murphy & Nemmers, 1978; Sharp et al., 1993) attempted to determine the effects of traditional progressive resistance training on MMH tasks without including the MMH task in the training program. Murphy and Nemmers (1978) trained 13 female soldiers using both resistance training and running. Their goal was to improve the women's ability to load and fire howitzers. The soldiers performed three to five sets of five to fifteen repetitions of eight traditional resistance training exercises over 3 weeks. Subjects increased their running distance from 0.5 to 2.5 miles and strength from 20% to 38% (depending on the muscle group). The authors note that at the end of training, the women could meet prescribed rates of fire for 155-mm and 105-mm howitzers. However, no data relating to performance with the howitzers are presented. There is no evidence of a howitzer fire pretest so it is not known if the women could have met the firing rates before the training program. Also, the training program was so short that the strength improvements were probably attributable to neural adaptations rather than hypertrophy, as discussed here (Sales, 1988b).

Sharp et al. (1993) trained 18 men in 36 sessions (3 days per week, 12 weeks), using 10 traditional weight training exercises. For each exercise, the men performed three to five sets of a 10RM. MMH tasks consisted of a) 10 minutes of lifting a 41-kg box as many times as possible from floor to chest level and b) a 1RM for the same distance. After the training program, there was a 17% improvement in the 10-minute task (79 to 92 lifts per 10 minutes, $p < 0.05$) and a 23% improvement in the 1RM task (73 to 89 kg, $p < 0.05$). This study was the first to demonstrate that a well-designed general training program fashioned to improve muscle strength and endurance could augment men's performance of MMH tasks.

Analysis of Task-Specific and General Training Studies

All MMH studies cited in the previous two sections used male subjects, with one exception. Genaidy (1994) used both men and women but did not separate them in the data analysis.

The improvements seen in task-specific training studies may have been largely attributable to enhanced psychomotor learning, although some improvement in muscular strength and endurance undoubtedly occurred. Several authors (Asfour et al., 1984; Genaidy, 1991;

Genaidy, Bafna, et al., 1990; Genaidy et al., 1989) note that at least a portion of the gains in lifting capacity were attributable to improved MMH "technique." Further, all the task-specific training studies cited previously were conducted for no longer than 6 weeks and most for 4 weeks or fewer. It has been demonstrated that neural adaptations account for the majority of strength gains in the first few weeks of resistance training, with hypertrophy becoming a more dominant factor later in training (Moritani & deVries, 1979). Early neural adaptations include fuller activation of muscle prime movers, reduced co-contraction of antagonistic muscles, improved coordination of muscle involved in the intended movement and removal of inhibitory influences (Moritani & deVries, 1980; Ruther, Golden, Harris, & Dudley, 1995; Sales, 1988a).

Improvements in MMH capability seen in the general training study of Sharp et al. (1993) probably involved mainly improvements in muscle hypertrophy but also some generalized neural adaptations (e.g., improved motor unit recruitment patterns) that translated to MMH improvements. The study was 12 weeks long, allowing sufficient time for muscle hypertrophy to become the dominant factor in strength changes. Muscle hypertrophy is an important factor in strength and endurance gains because absolute muscle strength is proportional to the cross-sectional area of muscle tissue (Maughan, 1984; Tuttle, Janney, & Salzano, 1955).

An important practical question for the military involves the effectiveness of general physical training. General physical training is an integral part of the daily routine in the U.S. Army. Army Regulation 350-41 (Headquarters, Department of the Army, 1993) prescribes vigorous exercise three to five times per week during the normal duty day. There is a strong institutional pressure to adhere to this requirement. The importance of physical training is further emphasized to the individual soldier by the Army Physical Fitness Test (APFT). The APFT must be completed and passed twice a year; promotion and retention in service are tied to the results. General physical training is assumed to improve a soldier's ability to perform physical tasks (as well as the soldier's health). However, if physical capability is improved little or not at all, some of the time devoted to this activity might be better spent on specific skill-centered occupational training.

Physical Training and Road March Performance

Road marching is another task requiring carrying of loads, not necessarily in the hands, but generally on other parts of the body. It is a frequently performed military exercise and one might well question whether fitness training can improve this aspect of soldier performance. Two studies (Knapik et al., 1990; Kraemer, Vogel, Patton, Dziados, & Reynolds, 1987) examined

this. One investigation (Knapik et al., 1990) involved 102 male soldiers who were placed into one of four groups performing no, one, two, or four road marches per month. All groups completed 1 hour of daily physical training which included both resistance training (2 days a week) and cardiorespiratory training (3 days a week). Before and after the training, the soldiers were asked to complete a 20-km road march as fast as possible while carrying a 45-kg load. At the end of the training program, the groups performing road marching two or four times per month were significantly faster than the groups performing no marching or only marching once a month. There were no differences between the two- and four-march-per-month groups. This study shows that a task-specific training program can improve road marching.

Another study (Kraemer et al., 1987) used a general training approach. Kraemer et al. trained 35 male soldiers for 12 weeks in one of four programs. Program 1 involved upper and lower body resistance training with running. Program 2 involved upper body resistance training only with running. Program 3 involved both upper and lower body resistance training but no running. Program 4 involved running but no resistance training. All programs were conducted 4 days per week; in Programs 1 and 2, there were 4 days of resistance training and 4 days of running. Before and after the programs, soldiers were asked to complete as rapidly as possible a 3.2-km distance while carrying a total load of 45 kg. At the end of training, subjects in programs 1 and 2 significantly improved their road march completion time (15% and 11%, respectively) while subjects in Programs 3 and 4 (resistance training alone or running alone) did not. This study indicated that resistance training must be combined with cardiorespiratory training to improve road march capability.

OBJECTIVES

It is known from studies cited previously that women can increase their muscular strength as a result of progressive resistance training. However, it is not known if these strength improvements will translate to significant improvements in MMH capability or road-marching performance as has been found with men. Therefore, the major objective of this investigation was to examine the influence of a general fitness training program on women's MMH capability and road-marching performance. The fitness program emphasized resistance training but also included cardiorespiratory endurance training. Secondary objectives were to describe changes in body composition, body circumferences, muscle strength, and cardiorespiratory endurance in response to the fitness program.

METHODS

Subjects

Subjects were 21 female soldiers who volunteered for this investigation after a detailed briefing about the purposes and risks of the study. They gave their informed voluntary consent to participate and signed a volunteer agreement affidavit in accordance with Army Regulation 70-25 (Headquarters, Department of the Army, 1989). The study protocol was approved by the Human Use Review Committees of the Human Research and Engineering Directorate (HRED) of the U.S. Army Research Laboratory (ARL) and the Medical Research and Development Command.

All subjects were healthy as determined by a medical records review. The MOS distribution was eight military police, four personnel specialists, three administrative personnel, two food service personnel, one supply specialist, one medical person, one wheeled vehicle mechanic, one legal person. Subjects had a mean ($\pm$SD) time in service of 7.1 $\pm$5.8 years.

Only 13 subjects completed all phases of the study. Five subjects voluntarily left the study during training and three left on the advice of medical personnel. The MOS distribution of the 13 soldiers finishing the study was four military police, one personnel specialist, three administrative personnel, two food service personnel, one supply specialist, one medical person, and one wheeled vehicle mechanic. Average time in service for these 13 soldiers was 7.8 $\pm$6.0 years. Unless otherwise noted, further analysis of the data is based on the 13 subjects completing the study.

Study Design

The study involved a pretest-posttest design with 14 weeks of training interpolated between the two tests. The pretest and posttest were essentially identical as described next. Additional measures of strength and nutritional intake were obtained during the physical training period.

Pre-Training and Post-Training Measures

Anthropometry and Body Composition

Subjects' total body mass was obtained from a digital scale (Seca) and their stature from an anthropometer (GPM). The subjects' ages were determined from date of birth. Circumference measures were obtained from the upper arm, shoulders, chest, abdomen, thighs and calf (Clauser, Tebbetts, Bradtmiller, McConville, & Gordon, 1988; Lohman, Roche, & Martorell, 1988) using a fiberglass tape (Gulick).

Body density was measured by the underwater weighing technique (Fitzgerald, Vogel, Miletti, & Foster, 1988) with correction for residual lung volume (Wilmore, Vodak, Parr, Girandola, & Billing, 1980). Residual lung volume was determined by nitrogen dilution using a Gould Model 2180 spirometer. Percent body fat was calculated from body density using the Siri equation (Siri, 1961). Body fat mass was calculated by multiplying body mass by percent body fat (as a decimal). Fat-free mass was obtained by subtracting body fat mass from total body mass.

MMH Tasks

Subjects performed three MMH tasks, all of which involved lifting a 23- by 30- by 51-cm (9- by 12- by 20-inch) box from the floor. The box had handles on both sides located 11 cm (4.5 inches) from the base. A straight back, bent knee lifting technique was encouraged for all subjects but not required.

The first MMH task involved lifting the box from the floor to a shelf at knuckle height with as much weight as possible. The second task involved lifting the box from the floor to a shelf at chest height with as much weight as possible. These lifts are representative of typical military MMH tasks such as lifting tools, sandbags, projectiles or boxes of ammunition to various heights (Myers et al., 1984). For both lifts, a 1RM procedure was used (Fleck & Kraemer, 1987). Subjects began lifting a light mass, and the mass was progressively increased in a systematic manner (1 to 10 kg) until a mass was found that the subject could not lift. The last mass successfully lifted was recorded as the 1RM.

The third MMH task required subjects to lift a 15-kg box onto a shelf as many times as possible in 10 minutes. The distance lifted was from the floor to chest height. The box was lowered by two spotters on either side of the box. At the end of 5 minutes, subjects were

allowed a 1-minute rest. During this rest, subjects were asked for a rating of perceived exertion (RPE) (Borg, 1970) for the upper body, lower body, and overall. To obtain the RPE, subjects viewed a 15-point scale containing numbers ranging from 6 to 20. Every other number was associated with a verbal anchor ranging from "7 very very light" to "19 very very heavy." Subjects verbally provided a single numeric rating. At the end of 10 minutes of lifting, subjects were asked for a second RPE.

A previous study (Sharp et al., 1993) indicated that three trials were necessary to assure stable baseline performance of similar MMH tasks. Thus, three trials were used to determine reliability and establish a criterion score in the pre-training phase (Kroll, 1967; Safrit, 1976). In the post-training phase, only two trials were conducted since data analysis performed after these trials indicated no difference between trials. Each trial was separated by 5 to 7 days.

Road March Task

For the road march task, subjects completed a 5-km distance as fast as possible while carrying a load mass of 19 kg. The load mass included uniform and boots, estimated at 4 kg, and an all-purpose, lightweight, individual carrying equipment (ALICE) pack, symmetrically loaded so that the total mass was 15 kg. The march course was entirely on paved roads with virtually no grade.

One practice march was conducted so that subjects could become acquainted with the course and equipment. For this march, subjects walked at their own pace and no time was recorded.

Two days after the practice march, subjects completed a criterion march. Subjects were instructed to cover the 5-km distance as rapidly as possible and time was recorded at 1-km intervals. Two to five days after this march, a second criterion march was performed.

Two criterion pre-training marches were conducted because previous research (Kraemer et al., 1987) indicated that this was sufficient to assure stable baseline performance. Only one march was conducted in the post-training phase since data analysis demonstrated no march time differences between the two pre-training trials, supporting previous work (Kraemer et al., 1987).

Army Physical Fitness Test (APFT)

The APFT involved sit-ups, push-ups, and a 3.2-km run using the procedures described in Army Field Manual 21-20. Subjects performed as many sit-ups as possible in 2 minutes, as many push-ups as possible in 2 minutes, and ran a 3.2-km distance as fast as possible. Total points were calculated from the age- and gender-related standards in Army Field Manual 21-20 (Headquarters, Department of the Army, 1992).

Previous Physical Training

To help determine starting levels of training, soldiers were interviewed and asked a series of five questions about their previous physical training:

1. "How many times have you run in the last 2 months?"
2. "On average, how many miles did you run each time you ran in the last 2 months?"
3. "On average, how many minutes did you run each time you ran in the last 2 months?"
4. "How many times did you perform weight training in the last 2 months?"
5. "On average, how many minutes did you spend in weight training in the last 2 months?"

Resistance and Endurance Training

All instruction was given by an individual certified by the American College of Sports Medicine as a Health and Fitness Instructor and by the National Strength and Conditioning Association as a Strength and Conditioning Specialist.

The training program was 14 weeks long. The first 2 weeks (seven sessions) were reserved primarily for familiarization and instruction. Subjects were instructed about procedures, safety, proper resistance training techniques, weight room etiquette, exercise progression, clothing for various environmental conditions, shoe selection and how to monitor exercise heart rate. Subjects performed both resistance training exercises and running but the emphasis was on form and technique rather than training volume.

During the last 12 weeks of training, resistance exercises were performed 3 days per week on Mondays, Wednesdays, and Fridays, while cardiorespiratory training was performed 2 days per week on Tuesdays and Thursdays, as described next.

Resistance Training

Resistance training consisted of nine exercises using exclusively free weights. The exercises were the power clean, deadlift, squat, bench press, upright row, triceps extension, arm curl, lateral raises, and front raises. These exercises were selected to improve the strength of the muscle groups involved in MMH. Subjects were instructed to complete the larger muscle group exercises first and alternate arms and legs as much as possible. In the third, fourth, and fifth weeks of training (of the 14-week program), subjects preformed one, two, and three sets, respectively, of ten repetitions of each exercise. A mass was selected that would allow the subject to just complete the ten repetitions. This mass was selected both using trial-and-error methods and by using 75% of the 1RM as a guideline (Fleck & Kraemer, 1987). From the fifth to fourteenth weeks, subjects were encouraged to perform the maximum number of repetitions possible on the last set (as many as 13); if 13 repetitions could be completed, the mass was increased by 5% to 10%. At least one instructor (usually two) was present in the weight room at all times to actively monitor subjects and reinforce correct lifting techniques. Subjects kept a log of their training using the form shown in Appendix A.

To specifically improve performance of the APFT, soldiers performed push-ups on Tuesdays and Thursdays and sit-ups on Mondays, Wednesdays, and Fridays. For the first 7 weeks, subjects performed 75% of the repetitions they had performed on their pre-training APFT. They performed one, two, and three sets on weeks 2, 3, and 4, respectively. They performed three sets through week 7. Three sets were maintained and repetitions were increased to 80% of the pre-training APFT values during weeks 8 through 11. Three sets were maintained and repetitions were increased to 90% of the pre-training APFT values during weeks 12 through 14.

Strength Evaluation

To evaluate changes in strength, subjects performed a 1RM on six exercises during weeks 3, 7, and 14. The exercises were the squat, deadlift, bench press, upright row, arm curls and triceps extension. Subjects began lifting a light mass and the mass was increased progressively and systematically until a load was found that the subject could not lift. The last mass successfully lifted was recorded as the 1RM (Fleck & Kraemer, 1987).

Cardiorespiratory Endurance Training

Subjects were placed into one of three cardiorespiratory fitness groups based on their pre-training 2-mile run time and previous running history. Individuals ran together in these groups for the first 5 weeks. Initial mileage was set at 1.5 miles and increased over a 5-week period until all groups were running 3 miles. During this time, one instructor ran with each group. At the end of the 5-week period, subjects were allowed to run individually, all on the same course with at least one instructor (usually two) on the course at all times. Subjects were encouraged to decrease their time over the 3-mile distance in subsequent weeks. Subjects kept a log of their training as shown in Appendix B.

At week 6 (of the 14-week program), interval training was introduced and performed once a week thereafter. On interval days, subjects ran 2 miles, then performed four 402-meter (440-yard) repeats on a standard asphalt track. Initial running times were 15% faster than subjects' average 1/4 mile on the pre-training APFT 2-mile run. The work:rest ratio was initially 1:1.5 and was reduced to 1:1 as training progressed (Fox & Mathews, 1974). Since subjects began each interval in small groups, the rest interval, in practice, was about 3 minutes at the start of interval training and gradually reduced to fewer than 2 minutes as training progressed.

Nutritional Intake

Subjects completed 3-day dietary records during weeks 2, 6, and 13. Subjects were asked to complete a form (DINE® Healthy) indicating each food name, amount eaten, brand name or restaurant, and how each food was prepared. Sections for breakfast, lunch, dinner and snacks were included. They were told to complete the record for specific Sunday, Monday, and Tuesday periods. Dietary records were analyzed using the DINE® Healthy computerized nutritional system.

Injuries

An injury was defined as any musculoskeletal problem that caused the subject pain or concern and that persisted for several training sessions. Injuries occurring during the study were referred to a physical therapist. In two cases, subjects saw a physician without first consulting the investigators. Each complaint was diagnosed and treated, if necessary, by the medical personnel. Independent records were kept by both the trainer and medical personnel regarding the subject's condition and progress.

RESULTS

Previous Physical Activity

Table 4 shows the self-reported running activity of the subjects in the 2 months before the study began. Only one subject reported no running in this period, while seven subjects reported less than one time per week. For subjects who ran, average distances ranged from 1.5 to 3.0 miles per session and average durations ranged from 15 to 30 minutes per session. Six subjects had performed resistance training in the 2 months before the study but only two had performed regularly (at least once a week).

Exercise Adherence

Not all subjects attended all sessions. Activities such as mandatory unit training, muster formations, all day staff duty, shift work (especially for the military police), unit moves, and personal problems interfered with physical training. Because the study was conducted 5 days per week, there was no opportunity to compensate for missed training time. Also, injured subjects were not able to perform all exercises.

Table 4

Subjects' Self-Reported Running in the 2 Months Before the Study

	Run frequency (times/wk)	Run distance (miles)	Run duration (min/session)
M	1.3	2.2	23.4
SD	1.1	0.9	8.6
Range	0-3.0	0-3.5	0-30.0

Each resistance exercise that could not be performed because of an injury was counted as 1/10 of a missed session. Running that could not be performed because of an injury was counted as the total mileage completed divided by the total mileage planned for that session (e.g., a 1-mile run in place of a planned 3-mile run was counted as 1/3 of a complete session). Entire sessions that were missed were counted as such.

In the first 2 weeks of the program (familiarization and formal instruction) subjects attended an average ±SD of 962% of the sessions (only two subjects missed sessions). In the last 12 weeks of training, there were 36 resistance training sessions and 24 aerobic training sessions. Subjects attended an average ±SD 312 resistance training sessions and 202 aerobic training sessions. This amounted to an average ±SD adherence to the program of 865% for resistance training and 849% for aerobic training. Figure 1 shows that missed sessions were distributed fairly even over the 12 weeks. Periods having the largest number of missing sessions (weeks 5 and 11) occurred when subjects from one company had muster formation.

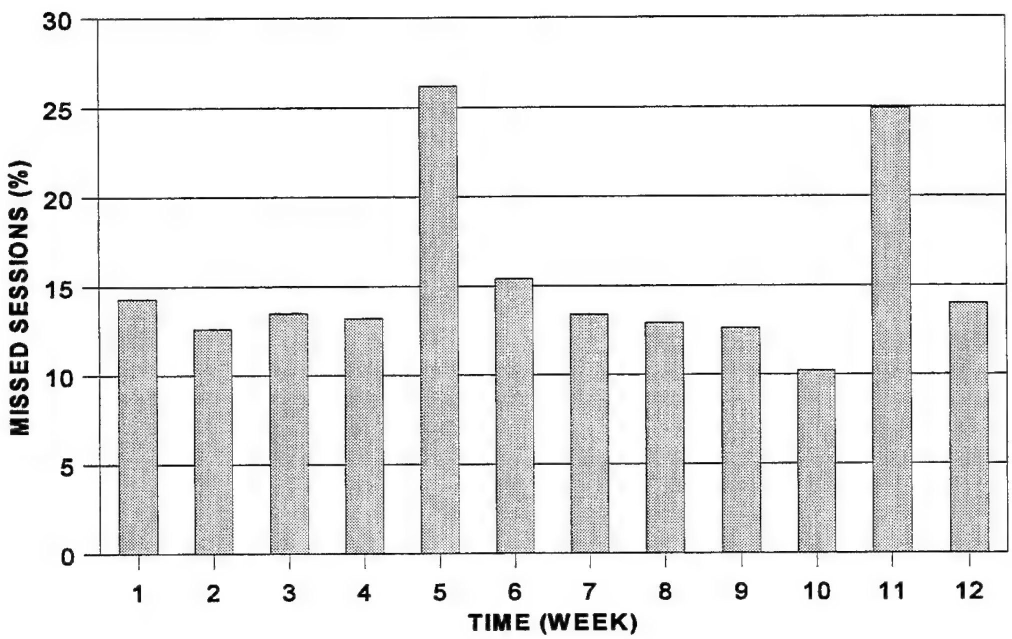

Figure 1. Missed sessions.

Physical Characteristics and Circumferences

At the start of the study, the average ±SD age of the subjects was 28.5 ±6.8 years. Table 5 shows the physical characteristics of the subjects in pre-training and post-training phases. The 2% (1.2 kg) average gain in total body mass was not statistically significant. However, body composition did change. Compared to pre-training, post-training body fat mass was reduced by 9% (1.6 kg), and fat-free mass increased by 6% (2.8 kg).

Table 6 shows pre-training and post-training circumferences. Of the six measurements taken, only the upper arm showed a significant increase. This amounted to an average of only 2% (0.6 cm) from pre-training to post-training.

Table 5

Physical Characteristics and Body Composition of the Subjects Before and After Training

		Pre-training	Post-training	p-value[a]
Stature (cm)	M	166.8	167.2	0.213
	SD	7.9	8.0	
Body mass (Kg)	M	67.0	68.2	0.118
	SD	8.9	9.3	
Body density (gm/ml)	M	1.0366	1.0426	0.006
	SD	0.016	0.013	
Body fat (percent)	M	27.6	24.9	0.005
	SD	7.3	6.1	
Body fat mass (Kg)	M	18.8	17.2	0.036
	SD	6.9	6.1	
Fat-free mass (Kg)	M	48.2	51.0	<0.001
	SD	5.7	6.2	

[a]From paired T-test

Table 6

Circumference Measures Before and After Training

		Pre-training	Post-training	p-value[a]
Upper arm (cm)	M	29.1	29.7	0.001
	SD	2.0	2.0	
Shoulders (cm)	M	106.1	106.4	0.543
	SD	5.1	4.8	
Chest (cm)	M	88.3	87.8	0.183
	SD	3.7	4.4	
Abdomen (cm)	M	83.4	82.3	0.247
	SD	9.0	7.6	
Thigh (cm)	M	55.5	56.1	0.267
	SD	4.7	4.8	
Calf (cm)	M	37.0	37.2	0.129
	SD	2.4	2.4	

[a]From paired T-test

MMH Capability

Table 7 shows the three trials obtained on the MMH tasks in the pre-training phase. There were significant differences among the trials for all tests. The Tukey test revealed that in all cases, Trial 1 differed significantly (p<0.05) from Trials 2 and 3, but there were no significant differences between Trials 2 and 3. Thus, Trials 2 and 3 were averaged and treated as the pre-training score (Kroll, 1967). Intraclass reliability coefficients (Safrit, 1976) for Trials 2 and 3 were 0.93, 0.99, and 0.97 for the floor-to-knuckle, floor-to-chest, and 10-minute repetitive lift, respectively.

Table 7

Pre-Training Trials on Manual Material-Handling Tasks

		Trial 1	Trial 2	Trial 3	p-value[a]	Critical difference[b]
Floor to knuckle max lift (kg)	M	61.8	68.1	68.6	0.012	4.8 (p=0.05)
	SD	14.8	10.3	9.0		6.6 (p=0.01)
Floor to chest max lift (kg)	M	44.6	48.9	48.8	0.001	2.2 (p=0.05)
	SD	6.5	6.1	6.5		3.0 (p=0.01)
Repetitive lift at 5 minutes (reps)	M	81.7	87.1	87.1	0.005	3.5 (p=0.05)
	SD	5.0	9.8	9.6		4.7 (p=0.01)
Repetitive lift at 10 minutes (reps)	M	154.2	164.6	168.5	<0.001	4.8 (p=0.05)
	SD	14.8	20.1	20.1		6.6 (p=0.01)

[a]From repeated measures analysis of variance (ANOVA)
[b]From Tukey Test

Table 8 shows the two trials taken on the MMH tasks during the post-training phase. There were no significant differences (p<0.05) between post-training Trials 1 and 2 on any of the tasks. Thus, Trials 1 and 2 were averaged and treated as the post-training score.

Table 8

Post-Training Trials on the Manual Material-Handling Tasks

		Trial 1	Trial 2	p-value[a]
Floor to knuckle max lift (kg)	M	82.0	80.4	0.196
	SD	9.9	12.2	
Floor to chest max lift (kg)	M	55.9	57.2	0.414
	SD	5.3	7.4	
Repetitive lift at 5 minutes (reps)	M	98.9	102.0	0.074
	SD	9.7	10.6	
Repetitive lift at 10 minutes (reps)	M	191.3	195.8	0.120
	SD	24.2	24.5	

[a]From repeated measures ANOVA

Table 9 shows the changes in performance of the three MMH tasks from pre-training to post-training. Subjects improved their performance of the floor-to-knuckle, floor-to-chest, and repetitive lifts by 19%, 16%, and 17%, respectively.

The average ±SD distance from the shelf to the ground for the floor-to-knuckle and floor-to-chest lifts were 70.0 ±4.2 cm and 119.6 ±7.0 cm, respectively.

Table 10 shows the RPEs obtained during pre-training and post-training. In the pre-training phase, Trials 2 and 3 were averaged to form the pre-training score; in the post-training phase, Trials 1 and 2 were averaged to form the post-training score. These values were selected so the RPE values would correspond with the MMH trials selected for analysis. There were no significant differences between the pre-training and post-training RPE scores.

Table 9

Pre-Training and Post-Training Scores for the Manual Material-Handling Tasks

		Pre-training score	Post-training score	p-value[a]
Floor to knuckle max lift (kg)	M SD	68.4 9.3	81.2 10.9	<0.001
Floor to chest max lift (kg)	M SD	48.8 5.3	56.6 5.9	<0.001
Repetitive lift at 5 minutes (reps)	M SD	87.1 9.3	100.5 9.8	<0.001
Repetitive lift at 10 minutes (reps)	M SD	166.6 19.8	194.5 24.1	<0.001

[a]From paired T-test

Table 10

Pre-Training and Post-Training Scores on the Rating of Perceived Exertion (RPE) During the Repetitive Lifting Task

		5-minute score			10-minute score		
		pre	post	p-value[a]	pre	post	p-value[a]
Upper body	M	13.4	13.4	0.901	14.1	14.0	0.925
	SD	1.5	1.7		1.8	1.6	
Lower body	M	13.4	13.3	0.908	14.2	14.1	0.783
	SD	2.3	2.0		2.6	2.3	
Overall	M	14.4	14.0	0.533	15.1	14.4	0.297
	SD	1.9	2.0		2.1	2.3	

[a]From paired T-test

Road March Performance

For road march criterion Trials 1 and 2, average ±SD 5-km march times were 44.9 ±3.3 and 44.4 ±2.6, respectively. There was no significant difference between these two march times ($t(12)=0.96$, $p=0.36$). Thus, Trials 1 and 2 were averaged and treated as the pre-training score. The intraclass correlation coefficient for the two trials was 0.89.

Table 11 shows the pre-training and post-training road march times at each kilometer of the march. Subjects completed the march significantly faster in the post-training phase ($t(12)=2.60$, $p=0.02$).

Table 11

Road March Times

		1 km	2 km	3 km	4 km	5 km
Pre-training Road march (min)	M	8.7	17.9	26.9	36.2	44.7
	SD	0.8	1.3	1.8	2.3	2.8
Post-training road march (min)	M	8.8	17.7	26.4	35.3	43.1
	SD	1.1	2.0	2.9	3.6	4.1

APFT Performance

The APFT results are shown in Table 12. In all events, there were significant changes from pre-training to post-training. Push-ups increased by 49% (14 repetitions), sit-ups increased by 13% (eight repetitions), and 3.2-km run time was reduced by 9% (1.9 minutes). Total APFT points increased 20% (42 points).

Strength Evaluations

Table 13 shows changes in 1RM strength in the six resistance training exercises examined during the course of training. There was a progressive improvement in 1RM strength during the course of the study. In all cases but the deadlift and arm curl, greater improvements occurred in the earlier part of training.

Table 12

APFT Scores Before and After Training

		Pre-training	Post-training	p-value[a]
Push-ups (reps)	M	28.7	42.7	<0.001
	SD	14.4	10.5	
Sit-ups (reps)	M	62.1	69.6	0.003
	SD	10.7	10.9	
Two-mile run (min)	M	20.3	18.4	<0.001
	SD	1.7	1.3	
Total points	M	215.7	258.0	<0.001
	SD	45.8	31.0	

[a]From paired T-test

Table 13

Changes in 1RM Scores During the Strength Evaluations

		Week 3 (kg)	Week 7 (kg)	Week 14 (kg)	p-value[a]	Critical difference[b]
Deadlift	M	81.5	88.3	95.5	<0.001	4.2 (p=0.05)
	SD	11.5	14.8	13.2		5.7 (p=0.01)
Squat	M	47.8	68.3	78.9	<0.001	6.3 (p=0.05)
	SD	14.4	15.9	14.8		8.6 (p=0.01)
Bench press	M	38.2	44.7	49.7	<0.001	2.4 (p=0.05)
	SD	6.8	7.4	7.9		3.2 (p=0.01)
Upright row	M	26.7	31.8	34.5	<0.001	1.5 (p=0.05)
	SD	3.2	3.4	3.9		2.0 (p=0.01)
Arm curl	M	20.6	23.6	28.2	<0.001	1.2 (p=0.05)
	SD	2.5	2.4	2.3		1.6 (p=0.01)
Triceps		10.0	13.2	15.9	<0.001	1.3 (p=0.05)
extension	SD	2.6	3.7	4.8		1.8 (p=0.01)

[a]From repeated measures ANOVA
[b]From Tukey Test

Nutritional Intake

Table 14 shows the data from the subjects' self-reported nutritional intake. There were no differences among the three time periods for any of the energy sources, vitamins, or minerals examined.

Table 14

Self-Reported Nutritional Intake

Variable		Week 2	Week 6	Week 13	p-value[a]
Total intake (kcals/day)	M	1711	1802	1802	0.807
	SD	529	391	656	
Total protein (gms/day)	M	66	64	72	0.345
	SD	19	18	25	
Total fat (gms/day)	M	65	72	75	0.542
	SD	19	15	31	
Total carbohydrates (gms/day)	M	216	216	213	0.991
	SD	78	61	97	
Vitamin A (re[b]/day)	M	789	770	808	0.941
	SD	491	473	623	
Vitamin C (mg/day)	M	90	88	92	0.989
	SD	58	48	95	
Iron (mg/day)	M	14.0	11.8	12.7	0.294
	SD	7.8	7.0	6.2	
Calcium (mg/day)	M	597	592	640	0.837
	SD	258	152	350	

[a]From repeated measures ANOVA
[b]RE = retinol equivalents (1RE=1μg retinol or 6 μg beta-carotene)

Injuries

Table 15 shows the injuries that occurred during the study. This includes information from all 21 soldiers who started the study. There was a total of 10 injuries, two of which were to the same subject (last two injuries in Table 15). Two injuries were evaluated by a physician and eight by the physical therapist. Four injuries were recurrent (i.e., subjects had had similar

therapist. Four injuries were recurrent (i.e., subjects had had similar symptoms previously) and three were because of accidents unrelated to the study. Four injuries involved the back, three the lower body, two the upper body, and one involved multiple areas of the body (car accident).

Table 15

Injuries During Study

Symptoms	Evaluation	Prescription or referral	Final status
Knee pain/swelling (recurrent, before study)	Knee joint effusion; minimal degenerative joint disease; MRI[a] showed lateral meniscus tear	Reduced squat training (2 weeks); orthopedic referral/ MRI	Continued in study
Chest pain because of fall on outstretched hand (unrelated to study)	Strain of scapular stabilizers and pectoralis major. Also mild subacromial bursitis	Reduced bench press and upright row training (5 days)	Continued in study
Foot pain (recurrent, before study)	Pes cavus (high arches), otherwise normal examination	Cushioned arch supports; podiatry referral (not completed during study)	Continued in study
Back pain from helping move household goods (unrelated to study)	Back strain	Stretching, TENS[b], reduced deadlift training (3 days)	Continued in study
Anterior leg pain (recurrent, before study)	Anterior tibialis shin splints	TENS and ice treatments; reduced running (2 weeks)	Voluntarily left study
Back pain	Back and hip strain	Stretching exercises, TENS, ultrasound; reduced deadlift and squat training (1 week)	Continued in study
Car accident (unrelated to study)	Multiple trauma		Removed from study
Back pain	Back strain	Medication, stretching	Removed from study
1. Wrist pain/swelling	1. Wrist joint sprain	1. Wrist brace, reduced upright row and power clean training (2 weeks)	1.Continued in study
2. Back pain (recurrent, before study)	2. Mechanical low back pain	2. Orthopedic referral and MRI[a] (not completed during study)	2.Removed from study

[a]MRI = magnetic resonance imaging [b]TENS = transcutaneous electrical nerve stimulation

DISCUSSION

The major finding of this investigation was that a general, traditional physical fitness training program was effective in improving the MMH capability and road-marching performance of U.S. Army women. These improvements occurred with a prescribed training duration of about 1 hour per day and training frequency of about 5 days a week. This is in consonance with the maximum amount of time normally allotted to this activity in the U.S. Army (Headquarters, Department of the Army, 1993). The program progressively increased training volume in a systematic manner during the 14-week training period.

Manual Material-Handling Performance

Our study employed a general, traditional physical training program that did not involve any exercise with the actual MMH tasks. The only times the subjects experienced the MMH tasks was in the pre-training and post-training phases. By following such a program and by using simple lifting tasks, we endeavored to minimize the influence of psychomotor learning. In fact, some learning did occur as evidenced by the increase in performance from Trial 1 to Trial 2 of all three MMH tasks in the pre-training test. However, there appeared to be little additional performance changes as evidenced by the small differences between Trial 2 and Trial 3 of the pre-training test and Trials 1 and 2 of the post-training tests.

In contrast to our investigation, a number of studies (Asfour et al., 1984; Asfour, Koshy, & Genaidy, 1991; Genaidy et al., 1994; Genaidy, 1991; Genaidy, Bafna, et al., 1990; Genaidy, Gupta, et al., 1990; Genaidy et al., 1989; Guo et al., 1992; Sharp & Legg, 1988) used task-specific training programs in which the same MMH task is used for testing and training. These training programs take advantage of both psychomotor learning and benefits from improved physical fitness as noted by some authors (Asfour et al., 1984; Genaidy, 1991; Genaidy, Bafna, et al., 1990; Genaidy et al., 1989).

Task-specific training studies involve less training volume and appear to result in much larger improvements in specific MMH tasks than do general training programs. Relative improvements of 26% to 99% are reported for maximal lifting or repetitive lifting in task-specific training studies (Asfour et al., 1984; Genaidy, Bafna, et al., 1990; Sharp & Legg, 1988). This contrasts with performance improvements of 16% to 19% for the women in our study and 19% to 23% for men in a similar traditional physical training study (Sharp et al., 1993). Task-specific training studies employing endurance time as a dependent measure (and involving complex motor

tasks) report improvements of 34% to 1350% (Genaidy et al., 1994; Genaidy, 1991; Genaidy, Bafna, et al., 1990; Genaidy, Gupta, et al., 1990; Genaidy et al., 1989; Guo et al., 1992).

The one major limitation of task-specific training is that performance improvements are largely restricted to the task for which the subjects are being trained. Generalized programs can improve performance of many tasks, provided that a wide variety of many muscle groups are involved in the exercise program. This type of training can be very advantageous in the military (as well as occupations such as police and fire fighting) where individuals are often called upon to engage in non-routine tasks and perform heavy physical labor in emergency situations.

The only other investigation to use a traditional fitness program and quantitatively test its effect on MMH capability was that of Sharp, et al. (1993) (details are in the Background section of this report), who trained and tested 18 men. Relative improvements in repetitive lifting ability (lifting 41 kg from floor to chest as many times as possible in 10 minutes) averaged 17%, similar to those found in our study, despite differences in the task. Comparisons between maximal floor-to-chest lifts are shown in Table 16. On the pre-training floor-to-chest lift, women in our study had 67% the strength of men in the study by Sharp et al. This is similar to the 60% value found in another investigation that made direct comparisons (Myers et al., 1984). After training, absolute increases in lifting capacity for the women in our study were only about half those of the men in the Sharp et al. study. Relative improvements were also greater in the Sharp et al. study.

Table 16

Comparisons Between Present Study and Sharp et al. for Maximum Floor-to-Chest Lift

Study	Pre-training (kg)	Post-training (kg)	Δ (kg)	Δ (percent)
Present	48.8	56.6	7.8	16.0
Sharp, et al., 1993	73.0	89.0	16.0	21.9
Present ÷ Sharp, et al., 1993	0.67	0.64	0.49	0.73

Differences between our study and that of Sharp et al. in floor-to-chest gains may be explained both in terms of dissimilarities between the two training programs and gender differences. Sharp et al. (1993) stated that their subjects trained three times per week, although the actual training adherence was not provided. Adherence to our training program was 86% of the scheduled sessions for resistance training, an average frequency of 2.6 times per week. Training volume was also greater in the Sharp et al. study since subjects performed three to five sets over the entire 12 weeks of training, as opposed to the three sets our subjects were performing by the fifth week of training.

Sharp et al. did not include aerobic training in their exercise routine. It has been demonstrated that aerobic training can interfere with strength improvements (Dudley & Djamil, 1985; Hickson, 1980), although the mechanism for this effect is not clear (Dudley & Fleck, 1987). Studies that have demonstrated this interference have used the same muscle groups for both forms of training. In the present study, aerobic training was running that involved primarily the lower body muscle groups. Studies indicate that the gastrocnemius, soleus, and to a lesser degree, the quadriceps are involved in running (Costill, Jansson, Gollnick, & Saltin, 1974; Õunpuu, 1994). The floor-to-chest lift is probably more limited by upper body muscle groups, which may be less affected by an unfavorable interaction between resistance and aerobic training. A larger level of interference would be expected for the floor-to-knuckle height lift.

We considered the potential interference between aerobic and resistance training before starting the investigation. We included aerobic training in our program for two reasons. First, past studies indicate that both types of training are necessary to improve road-marching performance (Kraemer et al., 1987). Second, subjects were volunteer soldiers who must take an APFT twice a year and achieve a passing score. The APFT includes a 3.2-km running event. We did not want to put the soldiers at a disadvantage since the APFT score is important for promotion and retention in service.

Besides differences between the two training programs, gender differences could explain a portion of the lower floor-to-chest gains in our study compared to Sharp et al. When men and women exercise in similar training programs, men generally show greater absolute strength gains (Cureton et al., 1988; Gettman et al., 1982; Hunter, 1985; O'Shea & Wegner, 1981; Wilmore, 1974; Wilmore et al., 1978). This is because men have a larger muscle mass (Cureton et al., 1988; Jackson & Pollock, 1978; Jackson, Pollock, & Ward, 1980; Knapik, Staab, & Harman, 1996; Maughan, Watson, & Weir, 1983) and can exercise with greater resistance, presumably resulting in the greater gains. However, relative gains in strength are greater for women, presumably

because of their lower initial state of training (Cureton et al., 1988; Gettman et al., 1982; Hunter, 1985; O'Shea & Wegner, 1981; Wilmore, 1974; Wilmore et al., 1978). In consonance with the literature, absolute 1RM gains were greater in the Sharp et al. study; these averaged 16, 25, and 34 kg, for the bench press, deadlift, and squat, respectively; in our study, these values were 12, 14, and 21 kg, respectively. Relative gains in 1RM in the Sharp et al. study averaged 33%, 19%, and 21% for the bench press, deadlift, and squat, respectively, while these values in our study were 44%, 17%, and 30%, respectively.

Physical Training and Army Occupational Performance

It is highly desirable to describe how a physical training program of the type used here may affect occupational performance in the U.S. Army. Army Regulation 611-201 (Headquarters, Department of the Army, 1994) provides a brief description of lifting requirements for various MOS which are listed in Appendix C. Army Regulation 611-201 does not provide the heights to which the loads are lifted nor does it provide the type of load (dimensions, shape, etc.). However, if some assumptions are made and the most physically demanding lifting requirement in the MOS is selected, it may be possible to estimate how physical training may improve occupational performance. The assumptions made are that a) the type of load is similar to that used in this study, b) loads are lifted to the heights described in this study (floor-to-knuckle or floor-to-chest height), and c) carrying requirements (when provided) are ignored.

Table 17 shows the analysis. There are 277 MOSs listed in Army Regulation 611-201, 230 (83%) of which have lifting requirements. If it is assumed that all lifts are from floor to knuckle height, then the average woman in this study could successfully perform in 92% of MOSs before training and 98% after training. Thus, under these assumptions, the average woman in this study met the lifting requirements in 15 additional MOSs after training. The average woman could not meet the described lifting requirements for four MOSs (12F, 54B, 88T, and 97G).

If it is assumed that all lifts are from floor to chest height, then the average woman in this study could successfully perform in 79% of MOSs before training and 88% after training. Thus, after training, the lifting requirements in 21 additional MOS were met under these assumptions. The average woman could not meet the described requirements in 27 MOSs even after training under these assumptions.

Table 17

Lifting Capability of Women in This Investigation and the Number of MOSs for Which These Women Could Meet the Most Demanding Lifting Requirement[a], Assuming That Lift was a 1RM From Floor to Knuckle Height or From Floor to Chest Height

	Floor to knuckle		Floor to chest	
	pre-training	post-training	pre-training	post-training
1RM lift (kg)	68	81	49	57
MOS with successful performance (N)	211	226	182	203

[a]From AR 611-201

A similar analysis can be made for the men in the Sharp et al. (1993) study using their floor-to-chest lift data. Before training, the average man could perform a 1RM lift of 73 kg, suggesting that he could perform successfully in 223 of the 230 MOSs with lifting requirements (97%). After training, the average man could lift 89 kg, suggesting that he could successfully perform in 227 of the 230 MOSs (99%). The MOSs with lifting requirements greater than 89 kg were 12F, 88T, and 97G.

Physical Training, Health, and Injuries

The benefits of physical fitness training are not limited to improved capacity for MMH and road marching. Physical activity has been shown to be related to improve worker health and longevity (Lakka et al., 1994; Paffenbarger, Hyde, Wing, & Hsieh, 1986; Powell, Caspersen, Koplan, & Ford, 1989; Sternfeld, 1992). Advantages for management accrue since employees who regularly perform fitness activities have lower medical cost, less illness-related absenteeism, and are more likely to be retained by the company (Baun, Bernacki, & Tsai, 1986; Bly, Jones, & Richardson, 1986; Bowne, Russell, Morgan, Optenberg, & Clarke, 1984; Tsai, Baun, & Bernacki, 1987). The benefits of regular physical exercise were recently acknowledged by the American Heart Association, which now lists physical inactivity as a major risk factor for cardiovascular disease, along with high blood pressure, high serum cholesterol and cigarette smoking (American Heart Association, 1992).

In addition to improvements in occupational performance and health, physical fitness training may reduce occupational injuries. Direct data showing that fitness training per se can reduce injuries are lacking. However, higher levels of strength and endurance are associated with fewer injuries in occupational work (Cady, Bischoff, O'Connell, Thomas, & Allen, 1979; Cady, Thomas, & Karwasky, 1985; Knapik, Ang, Reynolds, & Jones, 1993) and training (Barnes, Reynolds, Dettori, Westphal, & Sharp, 1995; Jones, Bovee, Harris, & Cowan, 1993; Jones, Cowan, et al., 1993). A job severity index that includes measures of strength has been shown to be related to occupational back injuries (Ayoub, Selan, & Liles, 1983).

Perceived Exertion

In the present study, there were no differences in pre-training and post-training RPE scores. This indicated that subjects did not perceive any greater exertion on the post-training repetitive lift than on the pre-training lift. This occurred despite the improvements in repetitive lifting performance. This is in consonance with studies that have used the same lifting task for training and testing (Genaidy et al., 1994; Genaidy, 1991; Genaidy, Bafna, et al., 1990; Genaidy, Gupta, et al., 1990; Genaidy et al., 1989; Sharp & Legg, 1988). These results suggest that traditional fitness training can also improve manual material-handling performance while subjects maintain a similar subjective impression of effort.

Road March Performance

The improvement in road march performance was 4% in the present study. Another study (Kraemer et al., 1987) that examined the influence of combined resistance and aerobic training on road march performance found improvements of 11% to 15%. These greater improvements may be attributable to differences in the load carriage task or differences in the training program. In the study by Kraemer et al., the load carriage task involved completing a 3.2-km distance while carrying a 46-kg load, as opposed to the 5-km, 19-kg load in our study. It is possible that type of physical training employed in both studies may improve performances involving shorter distances and heavier loads to a greater extent than performances involving longer distances with lighter loads.

More likely, differences in training volume account for the differential improvements. Training volume was considerably greater in the study by Kraemer et al. in which subjects performed both aerobic and resistance training 4 days per week. In our study, the average training frequency was 2.6 and 1.7 days per week for resistance and aerobic training, respectively

(based on adherence). In the study by Kraemer et al., aerobic training involved 40 minutes of continuous running and subjects attempted to increase distance each time; intervals involved running 402 and 805 meters (440 and 880 yards) and used 20% of the total aerobic training volume. In our study, aerobic training was about 30 minutes on average; interval training was not introduced until the sixth week and involved about 17% of the total aerobic training volume after this time. In Kraemer et al., resistance training involved more repetitions and a greater number of exercises than our study (16 versus 9 exercises).

While improvements in our study were smaller than those of Kraemer et al. (1987), results confirm that a traditional physical training program can increase road-marching performance even if road marching is not included in the training program. It further extends these findings to show that women can increase their road march performance if they exercise for only 1 hour per day, fewer than 5 days per week and use both resistance and aerobic training.

Body Composition

Changes in body composition were generally greater than those of most other investigations involving resistance training with women. These changes amounted to a 9% loss in body fat mass and a 6% gain in fat-free mass.

Since we used densitometric techniques, other investigations using this method are most directly comparable with our results (Brown & Wilmore, 1974; Butts & Price, 1994; Gettman et al., 1982; Wilmore, 1974). Findings from studies using skinfolds (Hunter, 1985; Mayhew & Gross, 1974; O'Shea & Wegner, 1981) must be questioned because exercise appears to affect fat loss differently in different parts of the body (Despres, Bouchard, Tremblay, Savard, & Marcotte, 1985). Thus, only studies using densitometry are considered in this section.

In comparable investigations, body fat losses ranged from 3% to 8% and fat-free mass gains, 2% to 3% (see Table 2). Women in our study had a higher training volume than women in these resistance training studies. One or two sets of each exercise were used in two investigations (Butts & Price, 1994; Wilmore, 1974). One study (Brown & Wilmore, 1974) had women train for 24 weeks, using a 3-day-a-week, five- to six-set program but only three to four exercises. Also, they used nationally ranked track and field athletes who began the study with relatively low body fat.

Our study also incorporated 2 days of running that could have further increased fat loss. Another study (Gettman et al., 1982) used a 3-day-per-week program with three sets of 12 to 15 repetitions and included some running as part of the program. Training intensity was only 40% of the 1RM as opposed to an estimated 75% of the 1RM in our study. Changes in body fat were comparable to those seen in our program. Changes in fat-free mass were greater in our program, possibly because of the higher exercise intensity for resistance training.

Dietary Intake

Changes in body composition were probably not attributable to changes in diet. Dietary variables did not differ among survey periods, although it should be remembered that the surveys were taken at only three points in the investigation, thus representing a small portion of the total dietary consumption.

There is reason to believe that subjects underestimated their dietary intake. Past studies report that food records are subject to underestimations of about 10% to 25% (Crawford, Obarzanek, Morrison, & Sabry, 1994; deCastro, 1994; Krall & Dwyer, 1987). In the present study, the self-reported total caloric intake of 1711 to 1802 kcals per day was probably less than that needed for subjects to maintain their body weight (Tuckerman & Turco, 1983). However, under-reporting may have been less of a problem in the present study because absolute intakes were not as important as differences among measurement periods. Subjects served as their own controls and a subject who under-reported may have been expected to do so across all three measurement periods (Dwyer, Krall, & Coleman, 1987).

Caloric distribution was about 35% fats, 50% carbohydrates, and 15% protein. Fat intake as a percentage of diet was higher than the 30% recommended by the American Dietetic Association (Callahan, 1992). Even if subjects under-reported their intake, protein consumption appears to have been sufficient. Self-reported protein intake averaged 1 gm/kg body weight, the exact recommendation of the American Dietetic Association for active individuals (Smith, 1987). This protein intake also supports the increase in subject's fat-free mass.

Circumference Changes

When assessing changes in circumference, it is necessary to remember that changes in subcutaneous fat cannot be distinguished from changes in muscle mass. Thus, gains in girth can result from increases in fat mass, muscle mass, or both. In the present study, subjects lost whole

body fat and gained whole body fat-free mass. About 50% of fat-free mass is assumed to be muscle mass (Benke & Wilmore, 1974). Our body composition data suggest that girth changes could indicate both losses in subcutaneous fat with concurrent increases in muscle mass, although it should be remembered that whole body composition changes do not reflect changes in localized parts of the body. Changes in girth were minimal and correspond to those reported in other studies of women (see Table 3), most of which were of shorter duration and lower training volume than our program (Bailey, Byrnes, Dickinson, & Foster, 1987; Brown & Wilmore, 1974; Hunter, 1985; Mayhew & Gross, 1974; Oyster, 1979; Wilmore, 1974). Upper arm circumferences have generally shown the greatest change in these studies, as in the present study. This may be at least partly attributable to the number of resistance training exercises that involve the upper arm. In the present study, the arm curl, triceps extension, bench press, upright row and push-ups were all exercises that trained muscle groups in this area.

APFT Changes and Aerobic Fitness

Improvements in APFT scores were expected because subjects specifically trained for the APFT events. The substantial change in the push-up was unexpected and there is no apparent explanation for this. Subjects commented informally that they had not been training with push-ups before the study, some because of the difficulty in performing them and some were discouraged at the few they were able to perform. One subject who could not perform a single push-up with correct technique at the start of the study completed 29 correct push-ups in the post-training test.

Aerobic fitness of the subjects increased as evidenced by the reduction in 2-mile run time from pre-training to post-training. Estimates of VO_2max obtained from these 2-mile run times (Mello, Murphy, & Vogel, 1984) indicate that subjects began the study with an average $\pm$SD VO_2max of 36.9 $\pm$3.1 ml per kg per minute and improved to 40.4 $\pm$2.2 ml per kg per minute. This latter value compares favorably with women on completion of basic combat training (Vogel, Patton, Mello, & Daniels, 1986), despite the older age of our subjects (29 years) compared to trainees (20 years). It also places our average subject in the upper 22% of women of similar ages based on an analysis of a large number of studies (Shvartz & Reibold, 1990).

CONCLUSIONS

The present investigation demonstrates that a physical training program that emphasizes resistance training and includes aerobic training will improve the manual material-handling capability and road-marching performance of female soldiers. This program involved only 1 hour per day, 5 days per week. Strength was still improving in the latter part of training (see Table 14), suggesting that a longer training program could have resulted in greater improvements in lifting capacity. This should be further investigated.

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APPENDIX A

RESISTANCE TRAINING LOG

RESISTANCE TRAINING LOG

NAME ____________________________ CARD NO. ___________

EXERCISE			DATE					
POWER CLEAN	1RM= 5RM= 10RM=	LBS						
		SETS						
		REPS						
DEADLIFT	1RM= 5RM= 10RM=	LBS						
		SETS						
		REPS						
BENCH PRESS	1RM= 5RM= 10RM=	LBS						
		SETS						
		REPS						
SQUAT	1RM= 5RM= 10RM=	LBS						
		SETS						
		REPS						
UPRIGHT ROWING	1RM= 5RM= 10RM=	LBS						
		SETS						
		REPS						
TRICEPS PRESSES	1RM= 5RM= 10RM=	LBS						
		SETS						
		REPS						
ARM CURLS	1RM= 5RM= 10RM=	LBS						
		SETS						
		REPS						
LATERAL RAISES	1RM= 5RM= 10RM=	LBS						
		SETS						
		REPS						
FRONT RAISES	1RM= 5RM= 10RM=	LBS						
		SETS						
		REPS						

APPENDIX B

AEROBIC TRAINING LOG

AEROBIC TRAINING LOG

NAME ______________________________ CARD NO. ________________

DATE	DISTANCE (MILES)	TIME (MIN)	HEART RATE (BEATS/MIN)	COMMENTS (WEATHER,MOOD,ETC.)

APPENDIX C

MOS WITH LIFTING, LIFTING AND CARRYING, WALKING OR CLIMBING REQUIREMENTS

MOSs WITH LIFTING, LIFTING AND CARRYING, WALKING OR CLIMBING REQUIREMENTS
(from AR 611-201, 1 Jul 94)

MOS NUMBER	MOS DESCRIPTION	
00B	DRIVER	Occasionally lifts and carries 44 kg Frequently lifts and carries 58 kg
00E	RECRUITER	
00R	RECRUITER/ RETENTION NCO	
00Z	COMMAND SERGEANT MAJOR	
01H	BIOLOGICAL SCIENCES ASSISTANT	
02	BAND MEMBER	Frequently lifts and carries 11 kg while marching 6 miles
02S	SPECIAL BAND MEMBER	Frequently lifts and carries 11 kg while marching 6 miles
02Z	BANDS SENIOR SERGEANT	Frequently lifts and carries 11 kg while marching 6 miles
11B	INFANTRYMAN*	Occasionally raises and carries 73 kg Frequently performs all other tasks carrying a minimum of 29 kg Occasionally walks 2 of 6 hours carrying 12 kg Frequently lifts and lowers 15 kg bags shoulder high Frequently road marches in mixed terrain up to 25 miles
11C	INDIRECT FIRE INFANTRYMAN*	Occasionally raises and carries 73 kg Frequently performs all other tasks carrying a minimum of 29 kg Occasionally walks 2 of 6 hours carrying 19 kg Frequently lifts and lowers 15 kg bags shoulder high Frequently lifts and carries rapidly 72 kg in 2 man teams (prorated 36 kg) Frequently lifts 12 kg objects 4 feet to place in vertical tube Occasionally lifts and lowers 128 kg in 2 man teams (prorated 64 kg) Frequently road marches in mixed terrain up to 25 miles
11H	HEAVY ANTI-ARMOR WEAPONS INFANTRYMAN*	Frequently performs all other tasks carrying a minimum of 29 kg Frequently raises and carries 73 kg Occasionally walks 2 of 6 hours carrying 19 kg Frequently lifts 25 kg 3 feet high Occasionally carries 69 kg 10 meters
11M	FIGHTING VEHICLE INFANTRYMAN*	Frequently performs all other tasks carrying a minimum of 29 kg Frequently raises and carries 73 kg Occasionally walks 2 of 6 hours carrying 19 kg Frequently lifts 40 kg 5 feet Frequently lowers 26 kg 3 feet Frequently lifts 20 kg waist high Occasionally lifts 36 kg chest high Frequently lifts 25 kg overhead

11Z	INFANTRY SENIOR SERGEANT*	Occasionally performs all other tasks carrying at least 29 kg Frequently raises and carries 73 kg Occasionally walks 2 of 6 hours carrying 19 kg
12B	COMBAT ENGINEER*	Frequently lifts 56 kg and carries 25 feet Occasionally lifts 41 kg and carries 25 feet Occasionally digs to fill 15 kg sandbags
12C	BRIDGE CREWMAN*	Frequently lifts 56 kg and carries 25 feet Occasionally lifts, carries, pushes and pulls 38 kg 15 feet Occasionally digs to fill 15 kg sandbags
12F	ENGINEER TRACKED VEHICLE CREWMAN*	Frequently lifts and lowers 98 kg Occasionally lifts and carries 41 kg and lowers 20 feet
12Z	COMBAT ENGINEER SENIOR SERGEANT*	
13B	CANNON CREWMAN*	Frequently lifts 83 kg 3 feet and carries 6 feet in 2-soldier teams (prorated 41 kg) Frequently lifts 110 kg 2 feet and carries 30 feet in 2-soldier teams (prorated 55 kg)
13C	TACFIRE OPERATIONS SPECIALIST*	Occasionally lifts/lowers 142 kg up/down 10 feet in 4-soldier teams (prorated 36 kg) Occasionally carries 91 kg 25 meters in 4-soldier teams (prorated 23 kg) Occasionally lifts/lowers 68 kg up/down 6 inches in 2-soldier teams (prorated 34 kg)
13E	CANNON FIRE DIRECTION SPECIALIST*	Frequently lifts 123 kg and carries 10 feet in 3-soldier teams (prorated 41 kg)
13F	FIRE SUPPORT SPECIALIST*	Frequently lifts and lowers 32 kg 3 feet Occasionally lifts, carries (8 feet) and lowers 34 kg Occasionally performs all other tasks carrying at least 29 kg Frequently digs, lifts and shovels 5 kg scoops of dirt
13M	MULTIPLE LAUNCH ROCKET SYSTEM CREWMEMBER*	Frequently lifts 14 kg 1 foot Occasionally lifts 20 kg 5 feet and carries 25 feet
13P	MULTIPLE LAUNCH ROCKET SYSTEM OPERATIONS/FIRE DIRECTION SPECIALIST*	Occasionally lifts/lowers and carries 23 kg 3 feet Frequently carries 45 kg in 2-soldier team (prorated 23 kg) Occasionally lifts/lowers 159 kg 8 feet in 4-soldier teams (prorated 40 kg)
13R	FIELD ARTILLERY FIREFINDER RADAR OPERATOR*	Frequently lifts 54 kg up/down 16 inches in 4-soldier team (prorated 14 kg)
13Z	FIELD ARTILLERY SENIOR SERGEANT	Occasionally lifts 13 kg and carries 3 feet
14D	HAWK MISSILE CREWMEMBER	Frequently lifts and lowers 113 kg in 3-soldier team (prorated 38 kg) Frequently lifts and lowers 23 kg 4 ft and carries 5 to 300 ft Frequently lifts and lowers 23 kg 4 feet and carries 5 to 300 feet Frequently climbs and descends 12 feet

14J	EARLY WARNING SYSTEM OPERATOR*	TBD
14R	LINE-OF-SIGHT-FORWARD-HEAVY CREWMEMBER*	Occasionally lifts and lowers 67 kg 3 ft as part of 4-soldier team (prorated 17 kg) Occasionally carries 67 kg 10 ft as part of 3-soldier team (prorated 22 kg) Occasionally climbs 10 feet
14S	AVENGER CREWMEMBER*	Frequently lifts and lowers 23 kg 3 ft Frequently carries 23 kg 164 ft Frequently climbs 6 feet
16D	HAWK MISSILE CREWMEMBER	Occasionally lifts 113 kg 5 ft in 3-soldier teams (prorated 38 kg) Frequently lifts 68 kg 3 ft and carries 30 ft
16E	HAWK FIRE CONTROL CREWMEMBER	Frequently lifts 68 kg 2 ft, climbs 6 feet and pivots 200 mils Frequently lifts 41 kg 3 ft Frequently runs 375 feet while carrying 44 kg
16P	CHAPARRAL CREWMEMBER*	Occasionally lifts and lowers 34 kg
16R	VULCAN CREWMEMBER*	Occasionally lifts and lowers 100 kg 2 feet in 2-soldier teams (prorated 50 kg) Occasionally carries 59 kg 25 ft in 2-soldier teams (prorated 29 kg) Occasionally climbs 5 feet
16S	MAN PORTABLE AIR DEFENSE SYSTEM CREWMEMBER*	Occasionally lifts and lowers 16 kg Frequently lifts and lowers 39 kg 4 ft in 2-soldier teams (prorated 19 kg) Frequently walks, runs, and climbs over varying terrain for a distance of 164 feet
16T	PATRIOT MISSILE CREWMEMBER	Occasionally lifts and carries 64 kg 5 ft in 4-soldier teams (prorated 16 kg) Occasionally lifts 10 kg 60 ft
16Z	AIR DEFENSE ARTILLERY SENIOR SERGEANT	Occasionally lifts 23 kg 6 ft and carries 10 m
18B	SPECIAL FORCES WEAPONS SERGEANT*	Occasionally raises and carries 73 kg on back Frequently walks at a brisk pace 4 of 6 hours carrying 12 kg Frequently performs all other tasks while carrying 29 kg evenly distributed over the entire body Frequently digs, lifts and shovels 10 kg scoops of dirt Frequently walks, crawls, runs and climbs over varying terrain for distances up to 25 miles Frequently runs for short distances
18C	SPECIAL FORCES ENGINEER SERGEANT*	Occasionally raises and carries 73 kg on back Frequently walks at a brisk pace 4 of 6 hours carrying 12 kg Frequently performs all other tasks while carrying 29 kg evenly distributed over the entire body Frequently digs, lifts and shovels 10 kg scoops of dirt Frequently walks, crawls, runs and climbs over varying terrain for distances up to 25 miles Frequently runs for short distances

18D	SPECIAL FORCES MEDICAL SERGEANT*	Occasionally raises and carries 73 kg on back Frequently walks at a brisk pace 4 of 6 hours carrying 12 kg Frequently performs all other tasks while carrying 29 kg evenly distributed over the entire body Frequently digs, lifts and shovels 10 kg scoops of dirt Frequently walks, crawls, runs and climbs over varying terrain for distances up to 25 miles Frequently runs for short distances
18E	SPECIAL FORCES COMMUNICATION S SERGEANT*	Occasionally raises and carries 73 kg on back Frequently walks at a brisk pace 4 of 6 hours carrying 12 kg Frequently performs all other tasks while carrying 29 kg evenly distributed over the entire body Frequently digs, lifts and shovels 10 kg scoops of dirt Frequently walks, crawls, runs and climbs over varying terrain for distances up to 25 miles Frequently runs for short distances
18F	SPECIAL FORCES ASSISTANT OPERATIONS AND INTELLIGENCE SERGEANT*	Occasionally raises and carries 73 kg on back Frequently walks at a brisk pace 4 of 6 hours carrying 12 kg Frequently performs all other tasks while carrying 29 kg evenly distributed over the entire body Frequently digs, lifts and shovels 10 kg scoops of dirt Frequently walks, crawls, runs and climbs over varying terrain for distances up to 25 miles Frequently runs for short distances
18Z	SPECIAL FORCES SENIOR SERGEANT*	Occasionally raises and carries 73 kg on back Frequently walks at a brisk pace 4 of 6 hours carrying 12 kg Frequently performs all other tasks while carrying 29 kg evenly distributed over the entire body Frequently digs, lifts and shovels 10 kg scoops of dirt Frequently walks, crawls, runs and climbs over varying terrain for distances up to 25 miles Frequently runs for short distances
19D	CAVALRY SCOUT*	Frequently lifts 45 kg 4 ft and carries 5 m Occasionally lifts 45 kg 4 ft and carries 5 m Frequently digs, lifts and shovels 10 kg scoops of dirt Frequently climbs 9 feet
19E	M48-M60 ARMOR CREWMAN*	Frequently lifts 57 kg 1 ft Occasionally lifts and pulls 68 kg 2 ft Frequently climbs 9 feet
19K	M1 ARMOR CREWMAN*	Frequently lifts 57 kg 1 ft Occasionally lifts and carries 59 kg 150 ft Frequently climbs 9 feet
19Z	ARMOR SENIOR SERGEANT*	

23R	HAWK MISSILE SYSTEM MECHANIC	Frequently lifts and lowers 23 kg 4 ft and carries 5 to 300 ft Occasionally lifts and lowers 11 to 45 kg 1 to 3 ft and carries 50 to 300 ft in 2-soldier teams (prorated 6 to 23 kg) Occasionally lifts and lowers 113 kg 5 ft and carries 300 ft in 3-solider teams (prorated 38 kg) Occasionally runs handling 113 kg 300 feet in 3-soldier teams (prorated 38 kg)
24C	HAWK FIRING SECTION MECHANIC	Occasionally lifts 113 kg as part of 3-soldier teams (prorated 38 kg) Constantly lifts and carries 9 kg Occasionally climbs 5 feet
24G	HAWK INFORMATION COORDINATION CENTRAL MECHANIC	Occasionally lifts and carries 45 kg Frequently lifts and carries 23 kg Occasionally climbs 5 feet
24H	HAWK FIRE CONTROL REPAIRER	Occasionally lifts and carries 43 kg 50 ft Frequently lifts and carries 17 kg
24K	HAWK CONTINUOUS WAVE RADAR REPAIRER	Occasionally lifts, lowers 3 ft and carries 23 kg 50 ft Frequently lifts and carries 29 kg Occasionally lifts 20 kg and climbs 5 ft
24M	VULCAN SYSTEM MECHANIC*	Frequently lifts and lowers 47 kg 2 ft Frequently carries 47 kg 100 yds in 2-soldier teams (prorated 23 kg) Frequently lifts 38 kg and climbs 2 ft
24N	CHAPARRAL SYSTEM MECHANIC*	Occasionally lifts 36 kg 3 ft Occasionally lifts and carries 36 kg 50 ft in 2-soldier teams (prorated 18 kg) Occasionally lifts, lowers 9 ft and carries 86 kg 20 ft in 4-soldier teams (prorated 22 kg)
24R	HAWK MASTER MECHANIC	TBD
24T	PATRIOT OPERATIONS AND SYSTEMS MECHANIC	Occasionally lifts and carries 39 kg in 2-soldier teams (prorated 20 kg) Occasionally lifts and carries 18 kg Occasionally climbs 5 feet
25L	AIR DEFENSE C&C SYSTEM OPERATOR	Occasionally lifts, lowers and carries 113 kg in 3-soldier teams (prorated 38 kg) Frequently lifts, lowers 3 ft and carries 36 kg 125 ft Occasionally lifts 29 kg and climbs 4.5 ft Occasionally climbs 4-1/2 feet
25M	MULTIMEDIA ILLUSTRATOR	Occasionally lifts and lowers 54 kg in 2-soldier teams (prorated 27 kg) Occasionally lifts/lowers and carries 23 kg
25R	VISUAL INFORMATION EQUIPMENT OPERATOR	Occasionally lifts and lowers 34 kg and carries 76 ft
25V	COMBAT DOCUMENTATION/ PRODUCTION SPECIALIST	Occasionally lifts/lowers and carries equipment weighing up to 34 kg

25Z	VISUAL INFORMATION OPERATIONS CHIEF	
27B	LAND COMBAT SUPPORT SYSTEM TEST SPECIALIST	Occasionally lifts and carries 23 to 45 kg Frequently lifts, lowers and carries 14 to 23 kg
27E	LAND COMBAT ELECTRONIC MISSILE SYSTEM REPAIRER	Frequently lifts and carries 47 kg 75 ft in 2-soldier team (prorated 24 kg) Frequently climbs 65 degree incline 7 feet carrying 47 kg in 2-soldier teams (prorated 24 kg) Frequently climbs 7 feet
27F	VULCAN REPAIRER	Occasionally lifts and carries 45 kg Frequently lifts and carries 23 kg Frequently lifts 23 kg and carries an indeterminable distance
27G	CHAPARRAL/REDEYE REPAIRER	Occasionally lifts and carries 32 kg Frequently lifts and carries 49 kg Frequently lifts 31 kg and climbs 4 ft
27H	HAWK FIRING SECTION REPAIRER	Occasionally lifts, lowers and carries 20 kg a distance of 50 ft Occasionally lifts and handles 25 kg
27J	HAWK FIELD MAINTENANCE EQUIPMENT/PULSE ACQUISITION RADAR REPAIRER	Occasionally lifts and carries 20 kg Occasionally lifts 20 kg and climbs 5 ft Occasionally climbs 4 feet
27K	HAWK FIRE CONTROL/CONTINUOUS WAVE RADAR REPAIRER	Occasionally lifts and lowers 3 ft 20 kg and carries 200 to 800 ft Occasionally climbs and descends 4 to 5 ft carrying 20 kg
27M	MLRS REPAIRER	Frequently lifts and lowers 25 kg and carries 10 ft Frequently lifts and lowers 34 kg climbing 4 to 6 ft Frequently lifts and lowers 68 kg and carries 4 to 6 ft in 2-soldier teams (prorated 34 kg)
27T	AVENGER SYSTEM REPAIRER	Frequently lifts and lowers 34 kg 3 to 4 ft Frequently climbs and descends platform ladder 4 ft with 34 to 44 kg and carries 20 to 100 ft in 2-soldier team (prorated 22 kg) Frequently lifts and lowers 44 kg 3 to 4 ft and carries 20 to 100 ft as part of 2-soldier team (prorated 22 kg)
27X	PATRIOT SYSTEM REPAIRER	TBD
27Z	MISSILE SYSTEMS MAINTENANCE CHIEF	
29E	RADIO REPAIRER	Occasionally lifts and lowers 79 kg in 2-soldier teams (prorated 40 kg) Frequently lifts and carries 34 kg 10 ft
29J	TELECOMMUNICATIONS TERMINAL DEVICE REPAIRER	Occasionally lifts/lowers and carries 77 kg in 2-soldier teams (prorated 39 kg) Occasionally lifts/lowers and carries 45 kg in 2-soldier teams (prorated 23 kg) Occasionally handles 45 kg in constrained area

29N	SWITCHING CENTRAL REPAIRER	Frequently lifts, carries, pushes and pulls 135 kg in 2-soldier teams (prorated 67 kg) Occasionally lifts/lowers and carries 202 kg 30 to 60 ft in 4-soldier team (prorated 51 kg)
29S	COMMUNICATIONS SECURITY EQUIPMENT REPAIRER	Occasionally lifts/lowers and carries 34 kg 10 ft Occasionally lifts/lowers and carries 23 kg 80 ft Frequently lifts/lowers 10 kg
29W	ELECTRONIC MAINTENANCE SUPERVISOR	
29Z	ELECTRONIC MAINTENANCE CHIEF	
31C	SINGLE CHANNEL RADIO OPERATOR	Frequently lifts 19 kg Occasionally lifts 45 kg and carries 3 ft
31D	MOBILE SUBSCRIBER EQUIPMENT TRANSMISSION SYSTEM OPERATOR	TBD
31F	NETWORK SWITCHING SYSTEM OPERATOR	Occasionally lifts/lowers and carries 68 kg in 2-soldier teams (prorated 34 kg)
31L	WIRE SYSTEM INSTALLER	Occasionally lifts 45 kg Frequently lifts 23 kg Frequently climbs poles and trees to a height of 18 feet and works for extended periods of time
31M	MULTICHANNEL TRANSMISSION SYSTEMS OPERATOR	Occasionally lifts and carries 116 kg in 3-soldier team (prorated 39 kg)
31P	MICROWAVE SYSTEMS OPERATOR-MAINTAINER	Occasionally lifts/lowers and carries 59 kg in 2-soldier team (prorated 29 kg) Occasionally lifts/lowers and carries 16 kg
31S	SATELLITE COMMUNICATIONS SYSTEMS OPERATOR-MAINTAINER	Occasionally lifts/lowers and carries 64 kg in 2-soldier teams (prorated 32 kg) Occasionally lifts/lowers and carries 23 kg
31T	SATELLITE/ MICROWAVE SYSTEMS CHIEF	
31U	SIGNAL SUPPORT SYSTEMS SPECIALIST	Occasionally lifts 68 kg 1 ft in 2-soldier team (prorated 34 kg)
31W	TELECOMMUNICATIONS OPERATIONS CHIEF	
31Y	TELECOMMUNICATIONS SYSTEMS SUPERVISOR	
31Z	SENIOR SIGNAL SERGEANT	

33R	AVIATION SYSTEMS REPAIRER	Occasionally lifts and lowers 29 kg 4 feet in 2-soldier teams (prorated 15 kg) Occasionally lifts 29 kg and carries 1.5 feet in 2-soldier teams (prorated 15 kg)
33T	TACTICAL SYSTEMS REPAIRER	Occasionally lifts and lowers 45 kg 4 feet in 2-soldier teams (prorated 22 kg) Occasionally lifts 45 kg and carries 15 feet in 2-soldier teams (prorated 22 kg)
33Y	STRATEGIC SYSTEMS REPAIRER	Occasionally lifts and lowers 41 kg 3 feet in 2-soldier teams (prorated 20 kg) Occasionally lifts 14 kg and carries 50 feet Occasionally climbs antenna superstructures to a height of 400 feet
33Z	ELECTRONIC WARFARE/INTERCEPT SYSTEMS MAINTENANCE REPAIRER	
35G	MEDICAL EQUIPMENT REPAIRER	Occasionally lifts 113 kg 3 feet in 3-soldier teams (prorated 38 kg)
35U	MEDICAL EQUIPMENT REPAIRER, ADVANCED	Occasionally lifts and carries 30 kg
35Y	INTEGRATED FAMILY OF TEST EQUIPMENT OPERATOR/ MAINTAINER	TBD
36L	TRANSPORTABLE AUTOMATIC SWITCHING SYSTEMS OPERATOR	Occasionally lifts 36 kg Frequently lifts 18 kg
37F	PSYCHOLOGICAL OPERATIONS SPECIALIST	Occasionally lifts and lowers 45 kg 5 feet and carries 100 feet in 2-soldier teams (prorated 23 kg)
38A	CIVIL AFFAIRS SPECIALIST	Occasionally lifts and lowers 11 kg 3-5 feet Occasionally carries 11 kg 6-50 feet Occasionally walks/marches 1-20 miles
39B	AUTOMATIC TEST EQUIPMENT OPERATOR	Occasionally lifts 84 kg 3 feet in 2-soldier teams (prorated 42 kg) Occasionally lifts and lowers 20 kg and carries 30 feet Occasionally lifts and lowers 18 kg 3 feet
39C	TARGET ACQUISITION/ SURVEILLANCE RADAR REPAIRER	Occasionally lifts, lowers and carries 259 kg in 6-soldier teams (prorated 43 kg) Occasionally lifts, lowers and carries 69 kg in 2-soldier teams (prorated 35 kg)
39E	SPECIAL ELECTRONIC DEVICES REPAIRER	Occasionally lifts, lowers and pushes 77 kg in 2-soldier teams (prorated 39 kg) Occasionally lifts, lowers, pushes and carries 29 kg

39G	AUTOMATED COMMUNICATIONS COMPUTER SYSTEMS REPAIRER	Occasionally lifts and lowers 29 kg Occasionally carries 27 kg
42C	ORTHOTIC SPECIALIST	Frequently lifts and carries 45 kg in 2-soldier teams (prorated 23 kg)
42D	DENTAL LABORATORY SPECIALIST	Occasionally lifts 102 kg and carries a short distance in 4-soldier teams (prorated 26 kg)
42E	OPTICAL LABORATORY SPECIALIST	Occasionally lifts 45 kg and carries 100 meters in 2- or 3-soldier teams (prorated 23 or 15 kg)
43E	PARACHUTE RIGGER	Frequently lifts 113 kg and carries 100 feet in 4-soldier teams (prorated 28 kg) Occasionally lifts 113 kg and carries 30 feet in 4-soldier teams (prorated 28 kg) Frequently carries 34 kg 30 feet
43M	FABRIC REPAIR SPECIALIST	Frequently lifts 48 kg and carries 25 feet Occasionally lifts 36 kg 50 inches and carries 50 feet
44B	METAL WORKER	Occasionally lifts up to 54 kg and carries up to 25 feet Occasionally lifts up to 91 kg and carries up to 25 feet in 2-soldier teams (prorated 45 kg)
44E	MACHINIST	Frequently lifts 68 kg 4 feet and carries 50 feet in 2-soldier teams (prorated 34 kg) Occasionally lifts and lowers 91 kg in 2-soldier teams (prorated 45 kg)
45B	SMALL ARMS/ ARTILLERY REPAIRER	Occasionally lifts and lowers 68 kg 3 feet Occasionally carries 68 kg 25 feet in 2-soldier teams (prorated 34 kg)
45D	SELF-PROPELLED FIELD ARTILLERY TURRET MECHANIC*	Frequently lifts 45 kg 3 feet and carries 50 feet Occasionally lifts and lowers 99 kg in 2-soldier teams (prorated 49 kg)
45E	M1 ABRAMS TANK TURRET MECHANIC*	Occasionally lifts and lowers 99 kg in 2-soldier teams (prorated 49 kg) Frequently lifts 44 kg 3 feet and carries 50 feet
45G	FIRE CONTROL REPAIRER	Frequently lifts 79 kg 4 feet and carries 50 feet in 2-soldier teams (prorated 38 kg) Occasionally lifts 45 kg 40 inches and carries 50 feet
45K	ARMAMENT REPAIRER	Frequently lifts 36 kg 2 feet and carries 50 feet Occasionally lifts 135 kg 5 feet, carries 50 feet and climbs 4 feet in 3 soldier teams (prorated 45 kg) Occasionally lifts and lowers 99 kg in 2-soldier teams (prorated 49 kg)
45N	M60A1/A3 TANK TURRET MECHANIC*	Occasionally lifts and lowers 99 kg in 2-soldier teams (prorated 49 kg) Occasionally lifts 68 kg 10 feet and carries 50 feet in 2-soldier teams (prorated 34 kg) Frequently lifts 44 kg 3 feet and carries 50 feet
45T	BRADLEY FIGHTING VEHICLE SYSTEM TURRET MECHANIC*	Frequently lifts 44 kg 4 feet and carries 100 feet Occasionally lifts 40 kg 4 feet and carries 50 feet Occasionally lifts and lowers 99 kg in 2-soldier teams (prorated 49 kg)
46Q	JOURNALIST	Occasionally walks an undetermined distance over irregular terrain

46R	BROADCAST JOURNALIST	
46Z	PUBLIC AFFAIRS CHIEF	Occasionally walks an undetermined distance over irregular terrain
51B	CARPENTRY & MASONRY SPECIALIST	Occasionally lifts and lowers 64 kg Frequently lifts and carries 45 kg
51H	CONSTRUCTION ENGINEERING SUPERVISOR	Occasionally stands, stoops, walks, crawls and climbs
51K	PLUMBER	Occasionally lifts and carries 52 kg Frequently lifts and carries 23 kg
51M	FIREFIGHTER	Occasionally lifts and carries 77 kg Frequently lifts and carries 29 kg
51R	INTERIOR ELECTRICIAN	Occasionally lifts and carries 262 kg in 6-soldier teams(prorated 44 kg)
51T	TECHNICAL ENGINEERING SPECIALIST	Occasionally lifts and carries 23 kg Frequently lifts and carries 5 kg
51Z	GENERAL ENGINEERING SUPERVISOR	TBD
52C	UTILITY EQUIPMENT REPAIRER	Occasionally lifts and lowers 68 kg up/down 2 feet and carries 1 foot in 2-soldier teams (prorated 34 kg) Occasionally lifts/lowers and carries 23 kg
52D	POWER-GENERATION EQUIPMENT REPAIRER	Occasionally lifts/lowers 113 kg up/down 2 feet in 2-soldier teams (prorated 57 kg) Occasionally lifts and lowers 68 kg up/down 4 feet in 2-soldier teams (prorated 34 kg) Occasionally lifts/lowers and carries 19 kg
52E	PRIME POWER PRODUCTION SPECIALIST	Lifts and lowers 91 kg and carries 50 feet in 2-soldier teams (prorated 45 kg) Lifts and lowers 57 kg and carries 50 feet in 2-soldier teams (prorated 28 kg)
52F	TURBINE ENGINE DRIVEN GENERATOR REPAIRER	Occasionally lifts, lowers and carries 57 kg 12 feet Occasionally lifts, lowers and carries 36 kg 16 feet Occasionally lifts, lowers and carries 23 kg
52G	TRANSMISSION AND DISTRIBUTION SPECIALIST	Frequently lifts, carries and lowers 45 kg
52X	SPECIAL PURPOSE EQUIPMENT REPAIRER	TBD
54B	CHEMICAL OPERATIONS SPECIALIST	Constantly raises from horizontal to vertical position 108 kg 3 feet Frequently pushes and pulls 215 kg 3 feet (may require 2 soldiers) Constantly rasises from horizontal to vertical 108 kg, 3 feet Occasionally lifts and carries 39 kg 50 feet
55B	AMMUNITION SPECIALIST	Frequently lifts 33 kg 4 feet and carries 10 feet Frequently climbs 10 feet and pushes and pulls 54 kg 3 ft

55D	EXPLOSIVE ORDNANCE DISPOSAL	Frequently lifts 43 kg and carries 100 meters Frequently climbs 10 feet while carrying 43 kg Frequently digs, lifts and shovels 11 kg scoops of dirt
55G	NUCLEAR WEAPONS SPECIALIST	Frequently lifts 49 kg and carries 5 feet Occasionally carries 23 kg 2000 feet while wearing self-contained breathing radiological gear Occasionally climbs and descends irregular terrain carrying 23 kg
55Z	AMMUNITION SUPERVISOR	Occasionally climbs 8 feet and pushes and pulls 54 kg 2 ft Occasionally climbs 30 feet
57E	LAUNDRY AND SHOWER SPECIALIST	Occasionally lifts 159 kg 10 inches and carries 50 feet in 4-soldier teams (prorated 40 kg) Occasionally lifts 32 kg 4 feet and carries 50 feet Occasionally lifts 16 kg and climbs 3 feet Frequently digs, lifts and shovels 11 kg scoops of dirt for a distance of 183 feet
57F	MORTUARY AFFAIRS SPECIALIST	Frequently lifts 82 kg 4 feet and carries 50 feet in 3-soldier teams (prorated 27 kg) Occasionally digs, lifts, and shovels 2 kg scoops of dirt
62B	CONSTRUCTION EQUIPMENT REPAIRER	Occasionally lifts 91 kg and carries 2 feet in 2-soldier teams (prorated 45 kg) Frequently lifts and carries 34 kg Occasionally lifts/lowers, push and pull 150 ft/lbs
62E	HEAVY CONSTRUCTION EQUIPMENT OPERATOR	Occasionally lifts, carries and lowers 60 kg Frequently climbs on and off equipment
62F	CRANE OPERATOR	Occasionally lifts and carries 57 kg Frequently lifts and carries 23 kg Frequently climbs on and off equipment
62G	QUARRYING SPECIALIST	Occasionally lifts and carries 57 kg Frequently lifts and carries 23 kg Frequently climbs on and off equipment
62H	CONCRETE AND ASPHALT OPERATOR	Occasionally lifts and carries 57 kg Frequently lifts and carries 23 kg Frequently climbs on and off equipment
62J	GENERAL CONSTRUCTION EQUIPMENT OPERATOR	Occasionally lifts and carries 57 kg Frequently lifts and carries 23 kg
62N	CONSTRUCTION EQUIPMENT SUPERVISOR	Occasionally lifts and carries 45 kg
63B	LIGHT-WHEEL VEHICLE MECHANIC	Occasionally lifts 104 kg in 2-soldier teams (prorated 52 kg) Occasionally lifts 68 kg 6 feet, carries 50 feet and climbs 5 feet in 2-soldier teams (prorated 34 kg) Frequently lifts 34 kg and carries 50 feet
63D	SELF-PROPELLED FIELD ARTILLERY SYSTEM MECHANIC*	Occasionally lifts 186 kg 4 feet and carries 6 feet in 3-soldier teams (prorated 62 kg) Occasionally lifts 148 kg 1 foot (using a hoist) and carries 50 feet in 2-soldier teams (prorated 74 kg) Frequently lifts and lowers 32 kg 3 feet and carries 50 feet

63E	M1 ABRAMS TANK SYSTEM MECHANIC*	Occasionally lifts 123 kg 5 feet and carries 50 feet in 3-soldier teams (prorated 41 kg) Occasionally lifts 68 kg 5 feet and carries 50 feet in 2-soldier teams (prorated 34 kg) Occasionally lifts 91 kg 2 feet and carries 50 feet in 3-soldier teams (prorated 30 kg) Occasionally lifts 186 kg 4 feet and carries 6 feet in 3-soldier teams (prorated 62 kg) Frequently lifts 32 kg 3 feet and carries 50 feet
63G	FUEL AND ELECTRICAL SYSTEMS REPAIRER	Occasionally lifts 45 kg 3 feet and carries 50 feet Frequently lifts 32 kg 3 feet and carries 50 feet Occasionally lifts and lowers 100 kg in 2-soldier teams (prorated 50 kg)
63H	TRACK VEHICLE REPAIRER	Occasionally lifts 181 kg 4 feet and carries 50 feet in 4-soldier teams (prorated 45 kg) Frequently lifts 32 kg 5 feet and carries 50 feet Occasionally lifts and lowers 99 kg in 2-soldier teams (prorated 49 kg)
63J	QUARTERMASTER AND CHEMICAL REPAIRER	Occasionally lifts 45 kg 4 feet and carries 50 feet Occasionally lifts and lowers 100 kg in 2-soldier teams (prorated 50 kg) Frequently lifts 32 kg 4 feet and carries 50 feet
63N	M60A1/A3 TANK SYSTEMS MECHANIC*	Frequently lifts 32 kg 3 feet and carries 50 feet Occasionally lifts 123 kg 4 feet and carries 50 feet in 2-soldier teams (prorated 62 kg) Occasionally lifts 148 kg 4 feet and carries 50 feet in 3-soldier teams (prorated 49 kg) Occasionally lifts 186 kg 4 feet and carries 6 feet in 4-soldier teams (prorated 47 kg)
63S	HEAVY-WHEEL VEHICLE MECHANIC	Occasionally lifts 32 kg 3 feet and carries 50 feet Occasionally lifts 113 kg 4 feet and carries 10 feet in 2-soldier teams (prorated 57 kg) Occasionally lifts 68 kg 3 feet and carries 50 feet in 2-soldier teams (prorated 34 kg) Frequently lifts 32 kg and carries 50 feet
63T	BRADLEY FIGHTING VEHICLE SYSTEM MECHANIC*	Occasionally lifts 107 kg 4 feet and carries 25 feet in 2-soldier teams (prorated 54 kg) Occasionally lifts 39 kg 2 feet and carries 50 feet Occasionally lifts 148 kg 3 feet and carries 50 feet in 3-soldier teams (prorated 49 kg) Frequently lifts 32 kg and carries 50 feet Occasionally lifts 186 kg 4 feet and carries 6 feet in 4-soldier teams (prorated 47 kg)
63W	WHEEL VEHICLE REPAIRER	Occasionally lifts 100 kg as part of 2-soldier teams (prorated 50 kg) Occasionally lifts 186 kg 4 feet and carries 6 feet in 3-soldier teams (prorated 62 kg) Frequently lifts 32 kg 3 feet and carries 50 feet
63Y	TRACK VEHICLE MECHANIC	Occasionally lifts 148 kg 1 ft and carries 25 feet in 2-soldier teams (prorated 74 kg) Occasionally lifts 186 kg 4 feet and carries 6 feet in 3-soldier teams (prorated 62 kg) Frequently lifts 32 kg 3 ft and carries 50 ft
63Z	MECHANICAL MAINTENANCE SUPERVISOR	Occasionally climbs, crouches, reaches, pushes and pulls 18 kg

67G	UTILITY AIRPLANE REPAIRER	Occasionally lifts and carries 363 kg in 8-soldier teams (prorated 45 kg) Occasionally lifts 36 kg and climbs 5 feet
67H	OBSERVATION AIRPLANE REPAIRER	Constantly lifts 75 kg and carries 30 feet in 2-soldier teams (prorated 37 kg)
67N	UH-1 HELICOPTER REPAIRER	Constantly lifts 102 kg and carries 25 feet in 2-soldier teams (prorated 51 kg)
67R	AH-64 ATTACK HELICOPTER REPAIRER	Occasionally lifts 71 kg 3 feet and carries 25 feet in 2-soldier teams (prorated 36 kg) Occasionally climbs 6 ft, 5 inches
67S	OH-58D HELICOPTER REPAIRER	Constantly lifts a max of 41 kg and carries 50 feet Frequently lifts and lowers 37 kg 5 feet Carries 181 kg 50 feet in 4-soldier teams (prorated 45 kg) Lifts and lowers 34 kg 6 inches
67T	UH-60 HELICOPTER REPAIRER	Occasionally lifts/lowers 32 kg 20 feet Occasionally lifts, lowers and carries 18 kg 28 feet Occasionally lifts, lowers and carries 20 kg 13 feet Occasionally climbs 15 feet from ground to top of equipment using footholds and grip bars on equipment
67U	CH-47 HELICOPTER REPAIRER	Frequently lifts 45 kg and carries 30 feet Occasionally lifts 143 kg 20 feet in 4-soldier teams (prorated 36 kg)
67V	OBSERVATION/ SCOUT HELICOPTER REPAIRER	Constantly lifts 20 kg and carries 1/4 mile Constantly lifts and lowers 34 kg 6 inches Occasionally lifts 68 kg and carries 12 feet in 2-soldier teams (prorated 34 kg) Frequently lifts 181 kg and carries 50 feet in 4-soldier teams (prorated 45 kg) Occasionally lifts 23 kg and climbs 5 feet
67Y	AH-1 ATTACK HELICOPTER REPAIRER	Frequently lifts 104 kg and carries 5 feet in 4-soldier teams (prorated 26 kg) Frequently lifts and lowers 34 kg 6 inches
68B	AIRCRAFT POWERPLANT REPAIRER	Frequently lifts 102 kg and carries 5 feet in 40-soldier teams (prorated 26 kg)
67Z	AIRCRAFT MAINTENANCE SENIOR SERGEANT	
68B	AIRCRAFT POWERPLANT REPAIRER	Frequently lifts 102 kg and carries 5 feet in 4-soldier teams (prorated 26 kg) Frequently climbs 10 feet
68D	AIRCRAFT POWERTRAIN REPAIRER	Frequently lifts 245 kg and carries 3 feet in 4-soldier teams (prorated 61 kg) Frequently lifts 59 kg and carries 15 feet in 2-soldier teams (prorated 29 kg)
68F	AIRCRAFT ELECTRICIAN	Frequently lifts 39 kg 4 feet and carries 50 feet Occasionally lifts 25 kg 6 feet and carries 50 feet Frequently climbs 12 feet
68G	AIRCRAFT STRUCTURAL REPAIRER	Constantly lifts 23 kg and carries 50 feet Frequently climbs 12 feet
68H	AIRCRAFT PNEUDRAULICS REPAIRER	Frequently lifts 23 kg, carries 50 feet and lowers Occasionally lifts 32 kg and carries 20 feet

68J	AIRCRAFT ARMAMENT/ MISSILE REPAIRER	Frequently lifts/lowers and carries 36 kg Frequently lifts/lowers 113 kg up/down 5 feet, carries varying distances in 3-soldier teams (prorated 38 kg) Frequently lifts/lowers and carries 222 kg in 4-soldier teams (prorated 56 kg)
68K	AIRCRAFT COMPONENTS REPAIR SUPERVISOR	
68L	AVIONIC COMMUNICATION S EQUIPMENT REPAIRER	Occasionally lifts 44 kg and carries 50 feet in 2-soldier teams (prorated 22 kg)
68N	AVIONIC MECHANIC	Frequently lifts 26 kg and carries 1/4 mile
68P	AVIONIC MAINTENANCE SUPERVISOR	
68Q	AVIONIC FLIGHT SYSTEMS REPAIRER	Occasionally lifts 23 kg and carries 50 feet
68R	AVIONICS RADAR REPAIRER	Occasionally lifts 30 kg and carries 15 feet
68X	AH-64 ARMAMENT/ ELECTRICAL SYSTEMS REPAIRER	TBD
71C	EXECUTIVE ADMINISTRATIVE ASSISTANT	Occasionally lifts 9 kg and carries 1/4 mile
71D	LEGAL SPECIALIST	Occasionally lifts 9 kg and carries 50 feet
71E	COURT REPORTER	Occasionally lifts 14 kg and carries 10 feet
71G	PATIENT ADMINISTRATION SPECIALIST	Occasionally lifts 18 kg and carries short distances
71L	ADMINISTRATIVE SPECIALIST	Frequently lifts 9 kg and carries 3 miles
71M	CHAPLAIN ASSISTANT	Occasionally lifts, lowers, carries, pushes/pulls 34 kg
73C	FINANCE SPECIALIST	Occasionally lifts 5-10 kg vertically 1-5 feet and carries 300 feet
73D	ACCOUNTING SPECIALIST	Occasionally lifts 9 kg vertically 1-5 feet and carries 300 feet
73Z	FINANCE SENIOR SERGEANT	Occasionally lifts 11 kg and carries 100 feet
74C	RECORD TELECOMMUNICA TION CENTER OPERATOR	Occasionally lifts 68 kg 3 feet in 2-solder teams (prorated 34 kg) Occasionally lifts 45 kg and carries 4 feet in 2-soldier teams (prorated 23 kg)
74D	INFORMATION SYSTEMS OPERATOR	Occasionally lifts and lowers 62 kg and carries 300 feet in 2-soldier teams (prorated 31 kg) Occasionally lifts/lowers 26 kg and carries 150 feet Occasionally digs, lifts and shovels 10 kgs of dirt while crouching, stooping and kneeling
74F	SOFTWARE ANALYST	Occasionally lifts 23 kg and carries 4 feet

74Z	RECORDS INFORMATION SYSTEMS CHIEF	
75B	PERSONNEL ADMINISTRATIVE SPECIALIST	Occasionally lifts 11 kg and carries 1/4 mile
75C	PERSONNEL MANAGEMENT SPECIALIST	Occasionally lifts 11 kg and carries 1/4 mile
75D	PERSONNEL RECORDS SPECIALIST	Occasionally lifts 11 kg and carries 1/4 mile
75E	PERSONNEL ACTIONS SPECIALIST	Occasionally lifts 11 kg and carries 1/4 mile
75F	PERSONNEL INFORMATION SYSTEMS MANAGEMENT SPECIALIST	Occasionally lifts 5 kg and carries 30 feet
75Z	PERSONNEL SERGEANT	
76J	MEDICAL SUPPLY SPECIALIST	Occasionally lifts 23 kg and carries 6 feet
77F	PETROLEUM SUPPLY SPECIALIST	Frequently lifts 107 kg 8 inches in 2-soldier teams (prorated 53 kg) Frequently lifts 45 kg 4 feet and carries 50 feet Occasionally digs, lifts and shovels 10 kg scoops of dirt Occasionally climbs and descends 50 feet
77L	PETROLEUM LABORATORY SPECIALIST	Occasionally lifts 11 kg and carries 100 feet Occasionally lifts 45 kg 4 feet and carries 50 feet
77W	WATER TREATMENT SPECIALIST	Frequently lifts 43 kg, carries 12 feet and lowers in 2-soldier teams (prorated 22 kg) Frequently lifts 43 kg and carries 20 feet
79D	REENLISTMENT NCO	
81C	CARTOGRAPHER	Occasionally lifts and carries 7 kg
81Q	TERRAIN ANALYST	Occasionally lifts and carries 11 kg
81Z	TOPOGRAPHIC ENGINEERING SUPERVISOR	Occasionally lifts and carries 9 kg
82C	FIELD ARTILLERY SURVEYOR*	Occasionally lifts 45 kg 1 meter and carries 300 meters Frequently lifts 23 kg 1 meter and carries 10 meters Frequently lifts 29 kg 1 meter and carries 10 meters
82D	TOPOGRAPHIC SURVEYOR	Frequently lifts, carries and lowers 18 kg
83E	PHOTO AND LAYOUT SPECIALIST	Occasionally lifts, carries and lowers 34 kg Frequently lifts and lowers 18 kg
83F	PRINTING AND BINDERY SPECIALIST	Occasionally lifts and lowers 34 kg Frequently lifts, lowers and carries 20 kg

88H	CARGO SPECIALIST	Occasionally lifts 240 kg and carries 6 feet in 4-soldier teams (prorated 60 kg) Frequently lifts and carries 64 kg in 2-soldier teams (prorated 32 kg)
88K	WATERCRAFT OPERATOR	Frequently lifts 14-36 kg and climbs 15 feet Occasionally lifts 91 kg in 4-soldier teams (prorated 23 kg)
88L	WATERCRAFT ENGINEER	Occasionally lifts 91 kg and carries 50 feet in 4-soldier teams (prorated 23 kg) Frequently lifts 14 to 43 kg and climbs 15 feet
88M	MOTOR TRANSPORT OPERATOR	Occasionally lifts and pulls 59 kg
88N	TRAFFIC MANAGEMENT COORDINATOR	
88P	RAILWAY EQUIPMENT REPAIRER	Occasionally lifts and carries 227 kg in 3-soldier teams (prorated 76 kg) Frequently lifts 91 kg in 4-soldier teams (prorated 23 kg)
88T	RAILWAY SECTION REPAIRER	Frequently lifts 91-181 kg in 2-soldier teams (prorated 41-91 kg) Frequently lifts and carries 1361 kg in 16-soldier teams (prorated 85 kg)
88U	RAILWAY OPERATIONS CREWMEMBER	Occasionally lifts and carries 36 kg Frequently lifts and carries 9 kg
88X	RAILWAY SENIOR SERGEANT	Frequently climbs 4 feet
88Y	MARINE SENIOR SERGEANT	
88Z	TRANSPORTATION SENIOR SERGEANT	
91B	MEDICAL SPECIALIST	
91C	PRACTICAL NURSE	Frequently lifts 82 kg and carries short distance in 4-soldier teams (prorated 20 kg) Occasionally lifts 11 kg and carries short distance
91D	OPERATING ROOM SPECIALIST	Occasionally lifts 82 kg in 4-soldier teams (prorated 21 kg)
91E	DENTAL SPECIALIST	Frequently lifts 41 kg and carries short distance as part of team Occasionally lifts 82 kg and carries short distance in 4-soldier teams (prorated 21 kg)
91F	PSYCHIATRIC SPECIALIST	Occasionally lifts 159 kg and carries short distance in 6-soldier teams (prorated 26 kg) Frequently walks 3 miles
91G	BEHAVIORAL SCIENCES SPECIALIST	Occasionally lifts 5 kg and carries short distances
91H	ORTHOPEDIC SPECIALIST	Frequently lifts 45 kg 3 feet as part of team Occasionally lifts 82 kg and carries short distance in 3-soldier teams (prorated 27 kg)
91J	PHYSICAL THERAPY SPECIALIST	Frequently lifts 82 kg and carries short distance in 3-soldier teams (prorated 27 kg)

91L	OCCUPATIONAL THERAPY SPECIALIST	Occasionally lifts 45 kg and carries short distance in 2-soldier team (prorated 23 kg) Occasionally lifts 82 kg and carries short distance in 3-soldier teams (prorated 27 kg)
91M	HOSPITAL FOOD SERVICE SPECIALIST	Occasionally lifts 50 kg 24 inches and carries 3 yards in 2-soldier teams (prorated 25 kg) Occasionally lifts 29 kg and carries 50 feet
91N	CARDIAC SPECIALIST	Occasionally lifts 82 kg and carries short distance in 4-soldier teams (prorated 21 kg) Frequently lifts 23 kg and carries short distance as part of team
91P	X-RAY SPECIALIST	Occasionally lifts 82 kg and carries very short distance in 3-soldier teams (prorated 27 kg) Frequently lifts 10 kg and carries short distance
91Q	PHARMACY SPECIALIST	Frequently lifts 14 kg and carries long distances Occasionally lifts 36 kg and carries short distances
91R	VETERINARY FOOD INSPECTION SPECIALIST	Constantly lifts 45 kg and carries 6 feet in 2-soldier teams (prorated 23 kg) Frequently carries 30 kg 100 meters in 2-soldier teams (prorated 15 kg)
91S	PREVENTATIVE MEDICINE SPECIALIST	Frequently lifts 9 kg and carries long distances
91T	ANIMAL CARE SPECIALIST	Frequently lifts 57 kg and carries short distances as part of team Occasionally lifts 34 kg and carries short distance
91U	EAR, NOSE, AND THROAT SPECIALIST	
91V	RESPIRATORY SPECIALIST	Occasionally lifts 82 kg and carries short distance in 2-soldier teams (prorated 46 kg) Occasionally lifts 159 kg and carries short distances in 4-6 soldier teams (prorated 27-40 kg)
91W	NUCLEAR MEDICINE SPECIALIST	Frequently lifts 23 kg and carries short distances Occasionally lifts 29 kg and carries short distance
91X	HEALTH PHYSICS SPECIALIST	Occasionally lifts 23 kg and carries moderate distances
91Y	EYE SPECIALIST	Occasionally lifts 11 kg and carries short distance
92A	AUTOMATED LOGISTICAL SPECIALIST	Occasionally lifts 45 kg 5 feet Frequently carries 29 kg 15 feet
92B	MEDICAL LABORATORY SPECIALIST	Occasionally lifts 91 kg and carries short distance in 3-soldier teams (prorated 30 kg) Occasionally digs, lifts and shovels 10 kg scoops of dirt
93E	CYTOLOGY SPECIALIST	Occasionally lifts 23 kg and carries short distance
92Y	UNIT SUPPLY SPECIALIST	Frequently lifts, lowers and carries 45 kg Occasionally carries 45 kg up to 500 feet
92Z	SENIOR NONCOMMISSIONED LOGISTICIAN	
93B	AEROSCOUT OBSERVER	Occasionally lifts 16 kg and carries 10 feet Occasionally carries 16 kg 50 feet Constantly carries 14 kg 500 feet

93C	AIR TRAFFIC CONTROL (ATC) OPERATOR	Occasionally lifts/lowers, pushes and carries 211 kg 4 feet in 4-soldier teams (prorated 53 kg) Occasionally lifts/lowers 280 kg 6 inches and carries 20 feet in 8-soldier teams (prorated 35 kg) Occasionally walks/marches 250 feet carrying 27 kg
93D	AIR TRAFFIC CONTROL EQUIPMENT REPAIRER	Frequently lifts and carries 102 kg in 4-soldier teams (prorated 26 kg)
93F	FIELD ARTILLERY METEOROLOGICAL CREWMEMBER$	Occasionally lifts 125 kg 30 inches and carries up 30 meters in 2-soldier teams (prorated 62 kg)
93P	AVIATION OPERATIONS SPECIALIST	Occasionally lifts/lowers 14 kg up and down 4 feet and carries 10 feet Occasionally lifts/lowers 14 kg up and down 4 feet and carries 3 feet
94B	FOOD SERVICE SPECIALIST	Occasionally lifts 45 kg 2 feet and carries 100 feet in 2-soldier teams (prorated 23 kg) Frequently pushes, pulls lifts and carries 23 kg Occasionally digs, lifts and shovels 10 kg scoops of dirt
95B	MILITARY POLICE	Lifts a max of 36 kg with frequent lifting of 18 kg Occasionally lifts and carries 32 kg
95C	CORRECTIONS SPECIALIST	Lifts a max of 36 kg with frequent lifting of 18 kg
95D	CID SPECIAL AGENT	Lifts a max of 36 kg with frequent lifting of 18 kg
96B	INTELLIGENCE ANALYST	Occasionally lifts 17 kg and carries 50 feet in multi-soldier team
96D	IMAGERY ANALYST	Occasionally lifts 17 kg and carries 50 feet in multi-soldier team
96H	IMAGERY GROUND STATION (IGS) OPERATOR	
96R	GROUND SURVEILLANCE SYSTEMS OPERATOR	Constantly load bears 27 kg and walks 1 to 5 miles Frequently lifts 25 kg and carries 100 feet
96U	UNMANNED AERIAL VEHICLE OPERATOR	TBD
96Z	INTELLIGENCE SENIOR SERGEANT	
97B	COUNTER-INTELLIGENCE AGENT	Occasionally lifts 23 kg and carries 50 feet
97E	INTERROGATOR	Occasionally lifts 9 kg and carries 20 feet
97G	COUNTER-SIGNALS INTELLIGENCE SPECIALIST	Occasionally lifts and lowers 198 kg in 2-soldier teams (prorated 99 kg)
97Z	COUNTER-INTELLIGENCE/ HUMAN INTELLIGENCE SENIOR SERGEANT	

98C	SIGNALS INTELLIGENCE ANALYST	Occasionally lifts 28 kg and carries 10 feet
98D	EMITTER LOCATOR/ IDENTIFIER	Occasionally lifts 28 kg and carries 10 feet
98G	VOICE INTERCEPTOR	Frequently lifts 34 kg and carries 3 miles Occasionally lifts and carries 147 kg in 4-soldier teams (prorated 37 kg) Occasionally lifts 28 kg and climbs 3 feet
98H	MORSE INTERCEPTOR	Frequently lifts 34 kg and carries an indeterminable distance Occasionally lifts, pushes and pulls 28 kg
98J	NONCOMMISSIONED INTERCEPTOR/ ANALYST	Occasionally lifts 28 kg and carries 5 feet
98K	NON-MORSE INTERCEPTOR/ ANALYST	
98Z	SIGNALS INTELLIGENCE/ ELECTRONIC WARFARE CHIEF	

* = closed to women
TBD = to be determined (9 MOSs)

There are 277 MOSs: 230 MOSs (83%) have manual material handling requirements.
38 MOSs (14%) have no manual material handling requirements
9 MOSs (3%) have physical requirements TBD

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